DOE Solar Energy Program Overview

Market Trends, Strategy, R&D Pipeline, Next Steps

DOE Solar Energy Technologies Program
August 2007

For More Information:
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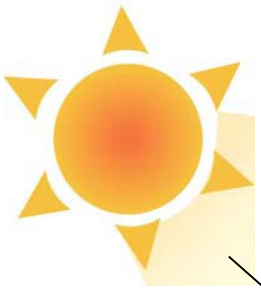
DOE's Solar Program researches and deploys high-performance and cost-competitive solar energy systems

Solar Hot Water Heaters

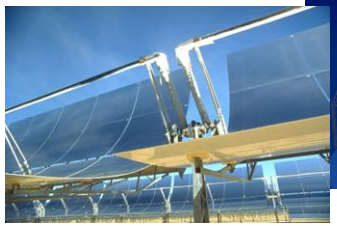
Distributed Generation, on-site or near point of use

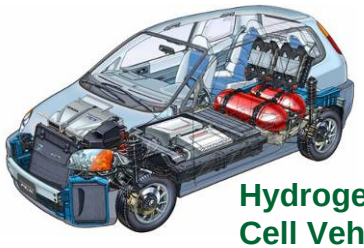


Photovoltaics

Centralized Generation, large-scale or utilities scale

Concentrating Solar Power (CSP)





Hydrogen for Fuel Cell Vehicles

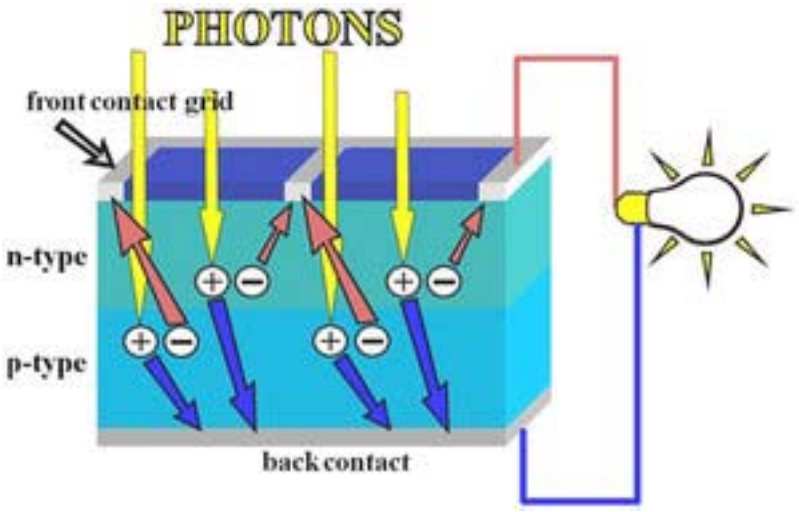
Solar energy provides renewable and carbon-free energy to help ensure secure and affordable energy supplies and to address climate change

Solar technologies convert the sun's radiation into electricity for on-site power or transmission to the grid

Two pathways of creating electricity from solar:

Photovoltaics

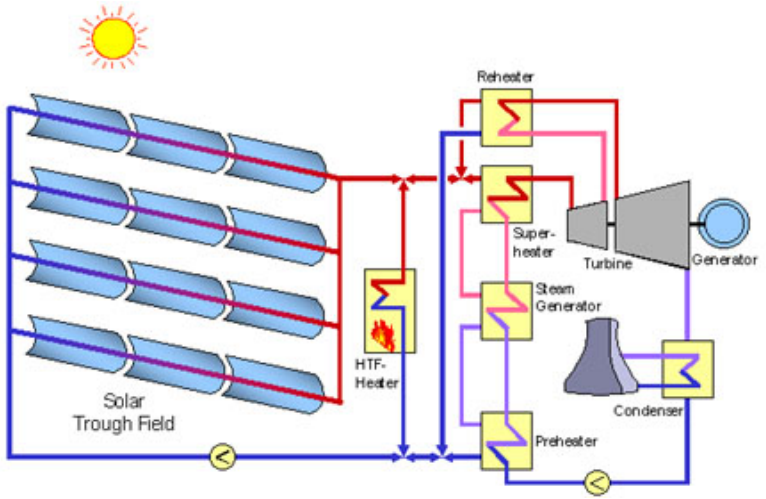
Cells of semi-conductors absorb photons and directly convert them into electrical current.



Can be used anywhere in the U.S.

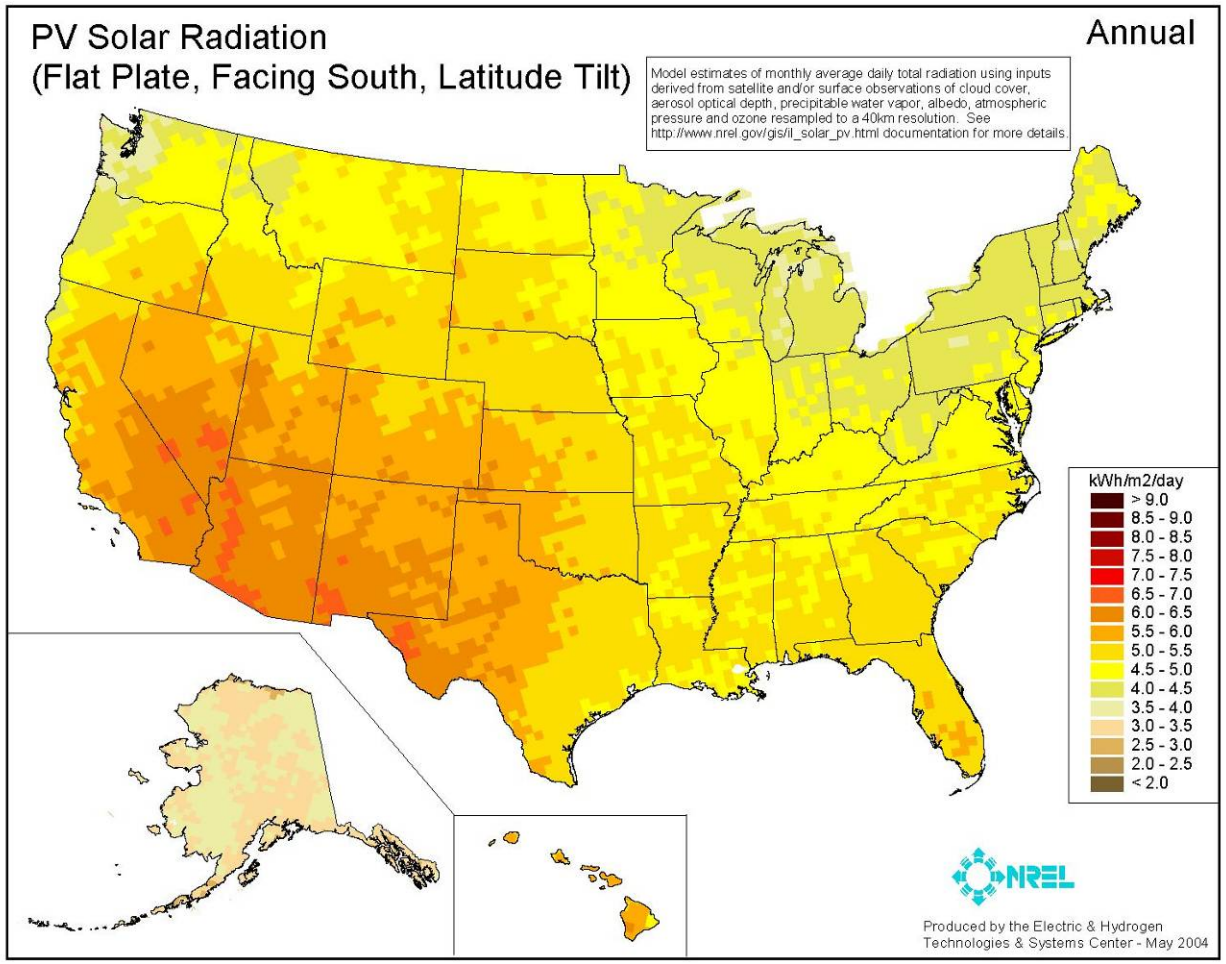
Concentrating Solar Power

Mirrors focus solar radiation to heat fluids that are used to drive electric generators.



Predominantly in the Southwest U.S. (requires direct sunlight)

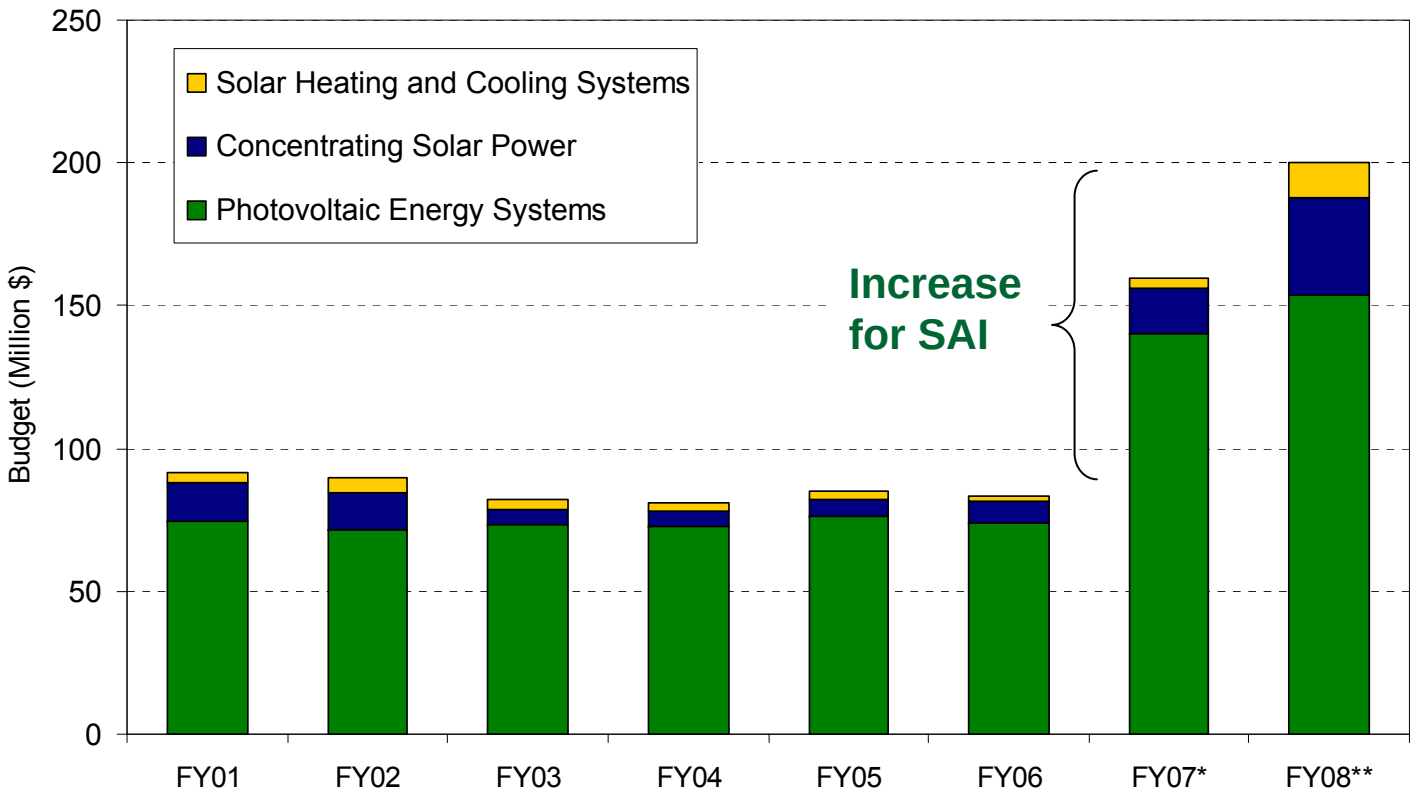
U.S. solar resources greatly outweigh the energy used



- Currently, solar provides less than .1% of the electricity used in the U.S.
- Covering less than .2% of the land on the earth with 10%-efficient solar cells would provide twice the power used by the world.
- For the U.S., a 100-mi by 100-mi area in the Southwest could provide all of our electricity.

The President's Solar America Initiative will focus on tapping this resource.

Funding for the Solar America Initiative will accelerate supply growth & adoption of PV/CSP technologies



With one last investment push, the Federal government will realize full value of 30-years of RD&D with a major new CLEAN energy source.

* President's Request for FY07 was $148M, final FY07 CR provided $159M.

** President's Request for FY08 was $148M, current House mark for FY08 is $200M.

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Solar America Initiative Across America

Activities:

Transforming Markets and Creating Demand

Codes and Standards:
Solar America Board of Codes and Standards (NM)

Utility Technical Outreach:
Solar Electric Power Association (DC)

State Technical Outreach:
Clean Energy Group (VT)
National Assn of Regulatory Utility Commissioners (DC)
National Conference of State Legislatures (CO)

Solar America Cities:
Ann Arbor (MI)
Austin (TX)
Berkeley (CA)
Boston (MA)
Madison (WI)
New Orleans (LA)
New York (NY)
Pittsburgh (PA)
Portland (OR)
Salt Lake City (UT)
San Diego (CA)
San Francisco (CA)
Tucson (AZ)

Solar America Showcases:
City of San Jose (CA)
Forest City Military Communities (HI)
Orange County Convention Center (FL)

PV Capacity Credit Valuation Study:
State University of New York (NY)
Tucson Electric Power (AZ)

SAI Federal Projects:
Architect of the Capitol (DC)
Smithsonian Institution (DC)

The Solar America Initiative (SAI) is accelerating the development of solar technologies, including photovoltaics (PV) and concentrating solar power (CSP) systems, with the goal of making them cost-competitive across all sectors by 2015. This work could not be successful without the collaboration of all stakeholders in the solar community. This map illustrates the location of several SAI participants…from Solar America City awardees who will be developing solar projects and building awareness in their respective communities to multinational corporations who will work in strategic alliances with other companies, national laboratories, and universities to tackle solar manufacturing challenges. It is truly a nationwide effort to create a Solar America.

Developing Products and Building Supply

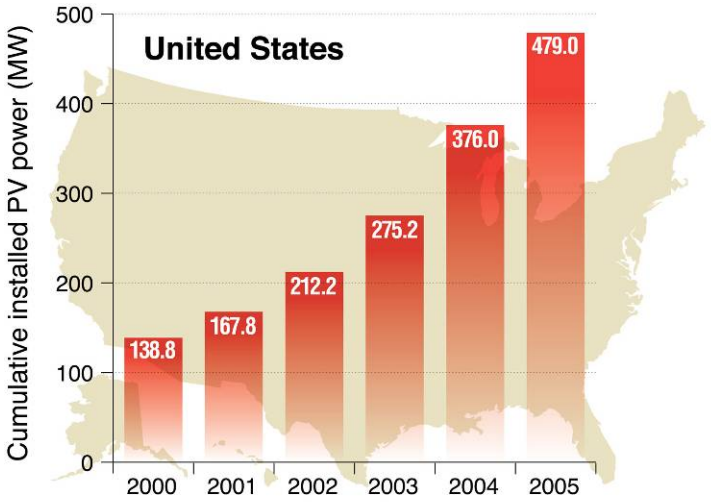
Technology Pathway Partnerships:
Amonix (CA)
Boeing (CA)
BP Solar (MD)
Dow Chemical (MI)
General Electric (DE)
GreenRay (MA)
Konarka (MA)
Miasolé (CA)
Nanosolar (CA)
Soliant (CA)
SunPower (CA)
United Solar Ovonic (MI)

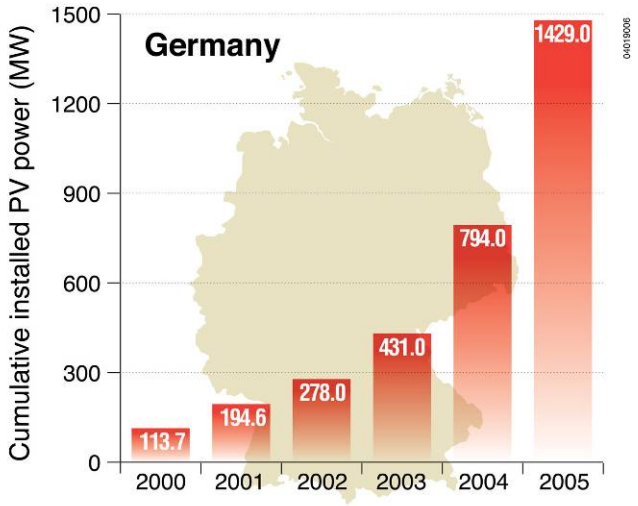
PV Module Incubator:
AVA Solar (CO)
Blue Square Energy (MD)
CaliSolar (CA)
EnFocus Engineering (CA)
MicroLink Devices (IL)
Plextronics (PA)
PrimeStar Solar (CO)
Solaria (CA)
SolFocus (CA)
SoloPower (CA)

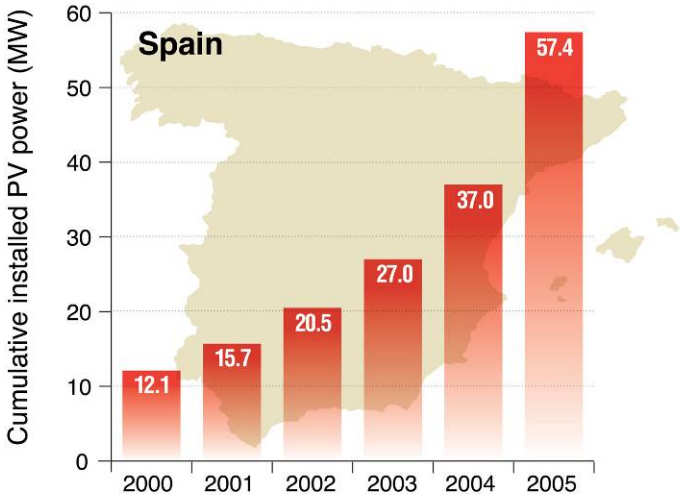
Photovoltaic Technologies

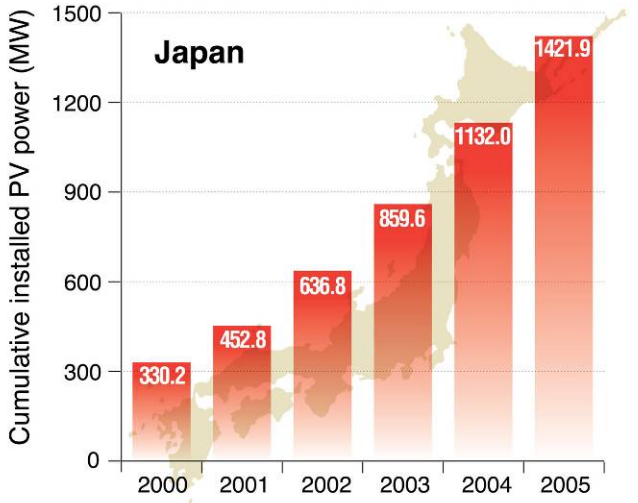
A Growing Source for Distributed & Centralized Electricity Generation

PV has historically been a marginal power source, but incentives have driven steep growth in installations





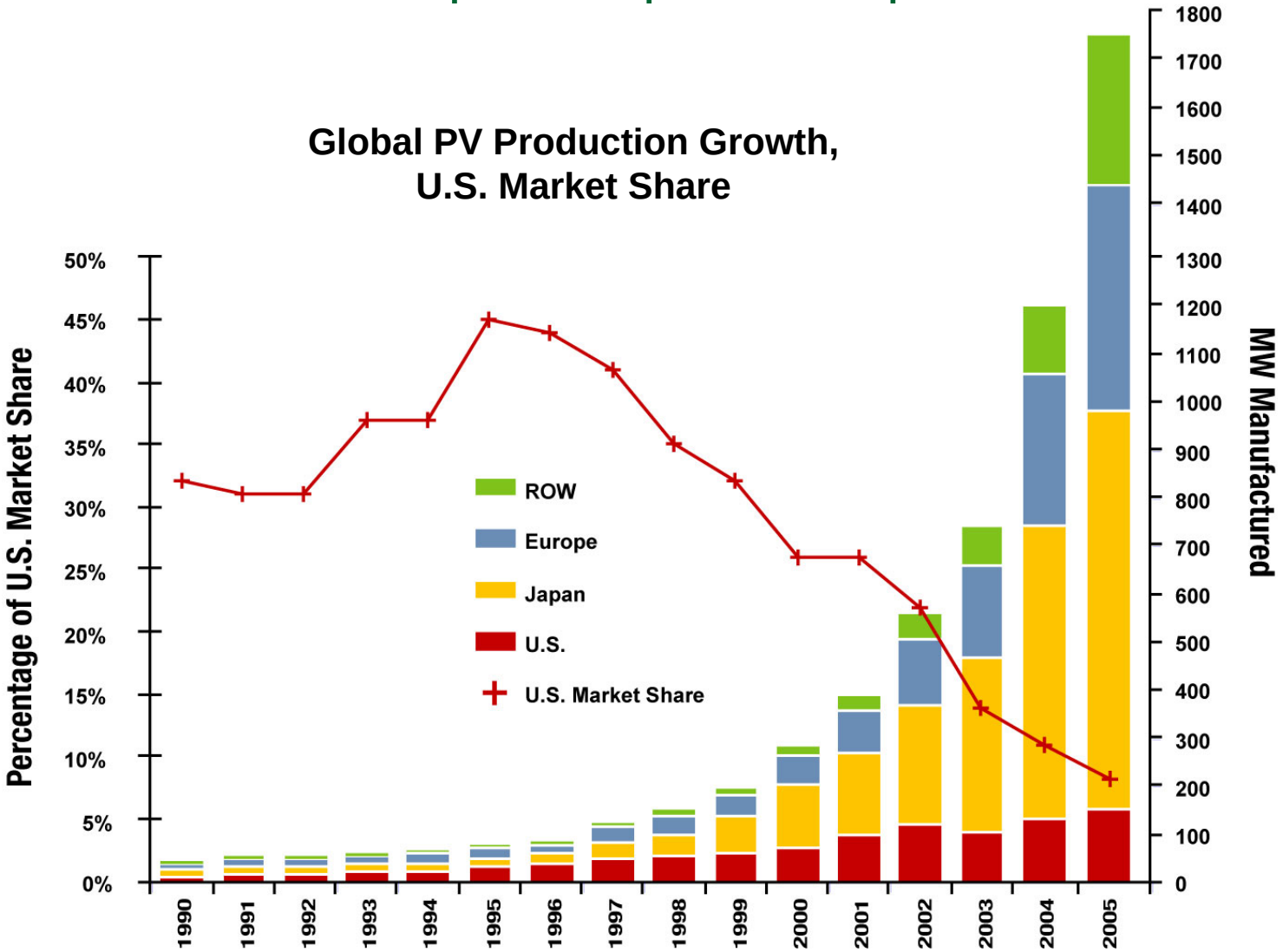




Source: International Energy Agency.

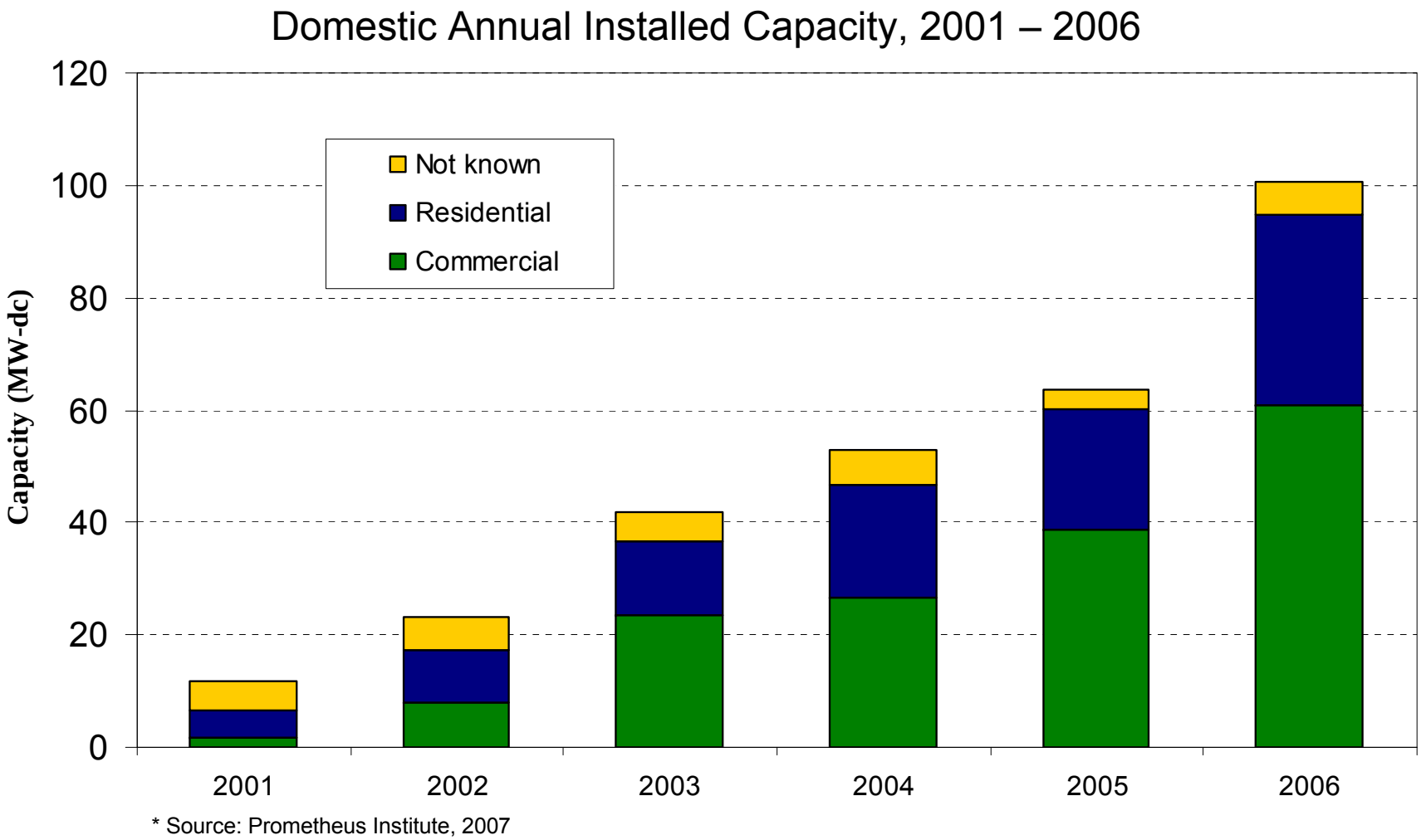
Incentive-driven demand is expanding production, but creating Si supply bottlenecks.

…But foreign incentives and R&D programs have driven worldwide competition past U.S. producers



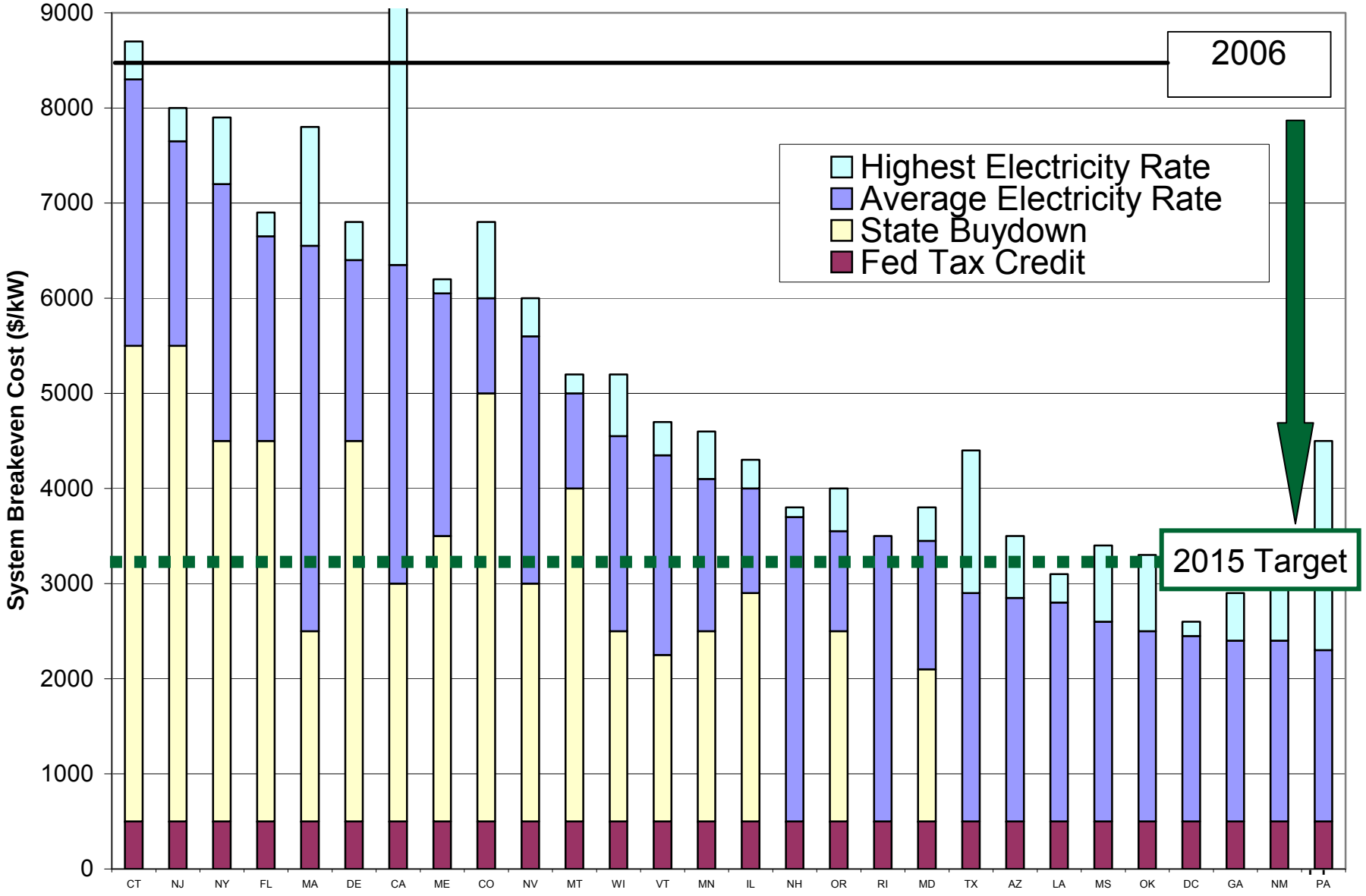
U.S. production now lags Japan and Germany, and China passed U.S. in 2006.

And now, State and Federal incentives are adding momentum to U.S. residential and commercial markets

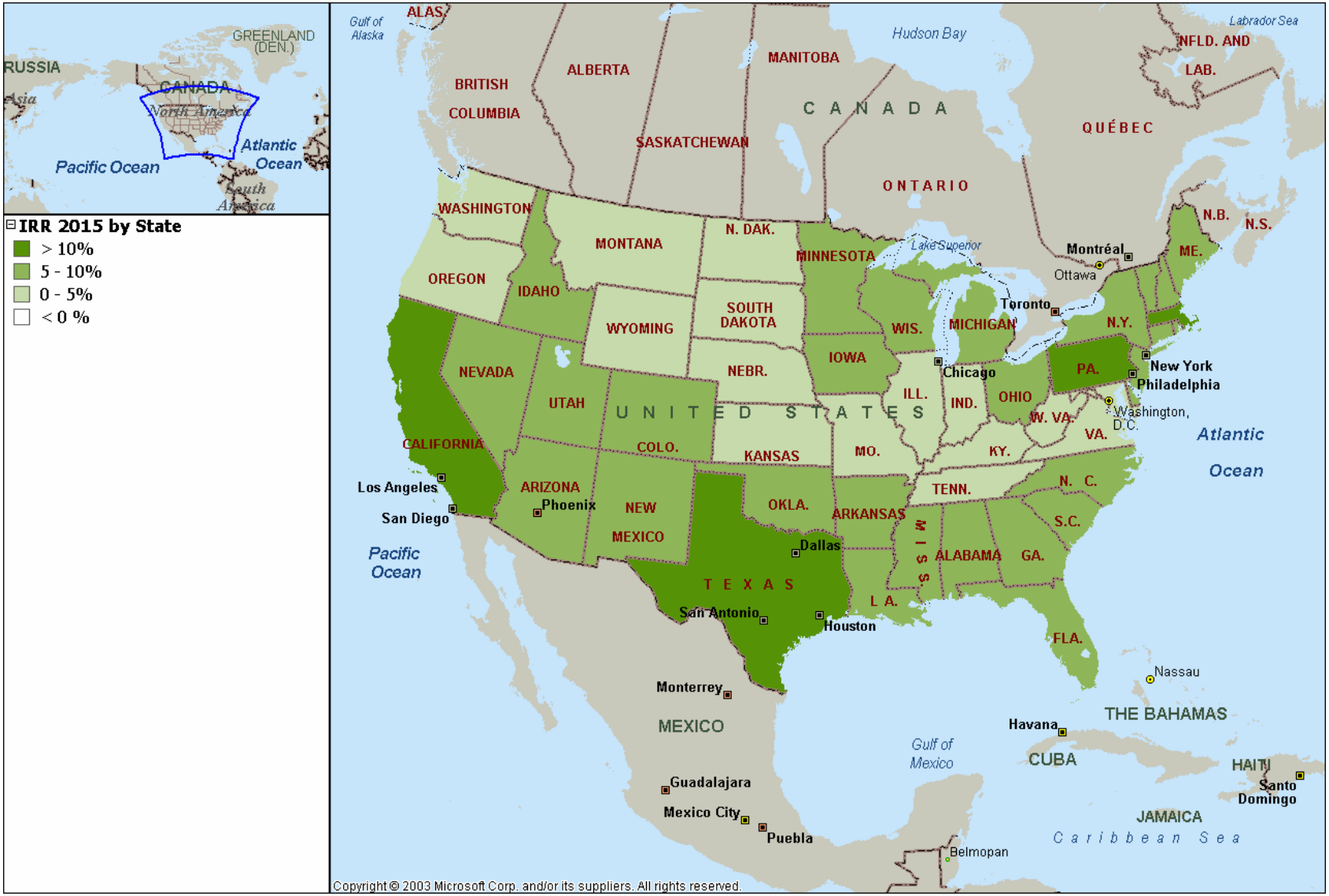


In 2006, the commercial sector accounted for 60% of total installed capacity, up from 13.5% in 2001. Government incentives have driven this growth.

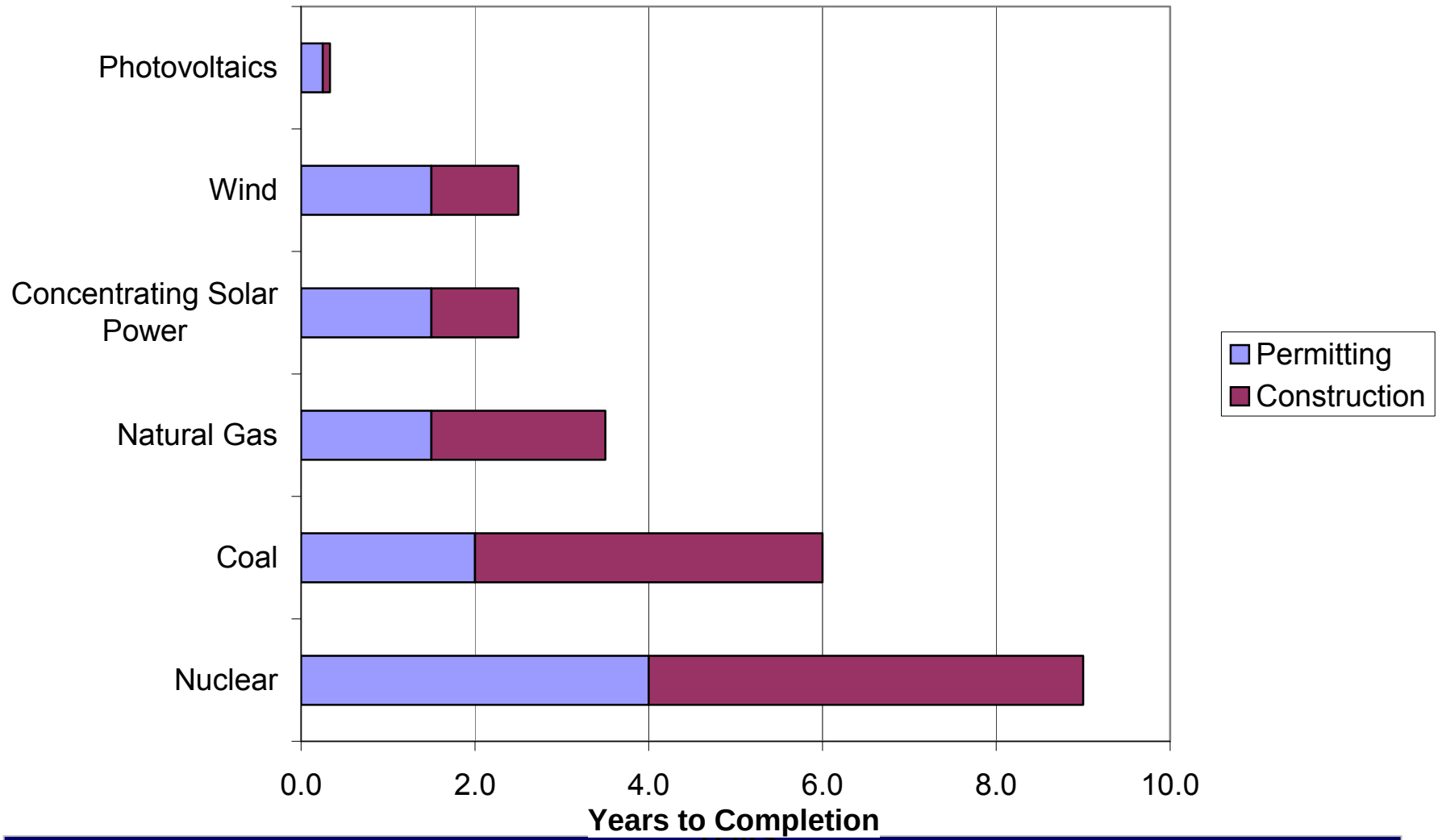
Convergence of PV cost reduction, rising electricity prices, and subsidies are opening market opportunities



In 2015, residential installations will exhibit attractive IRR for most major markets, especially CA, TX, PA, MA

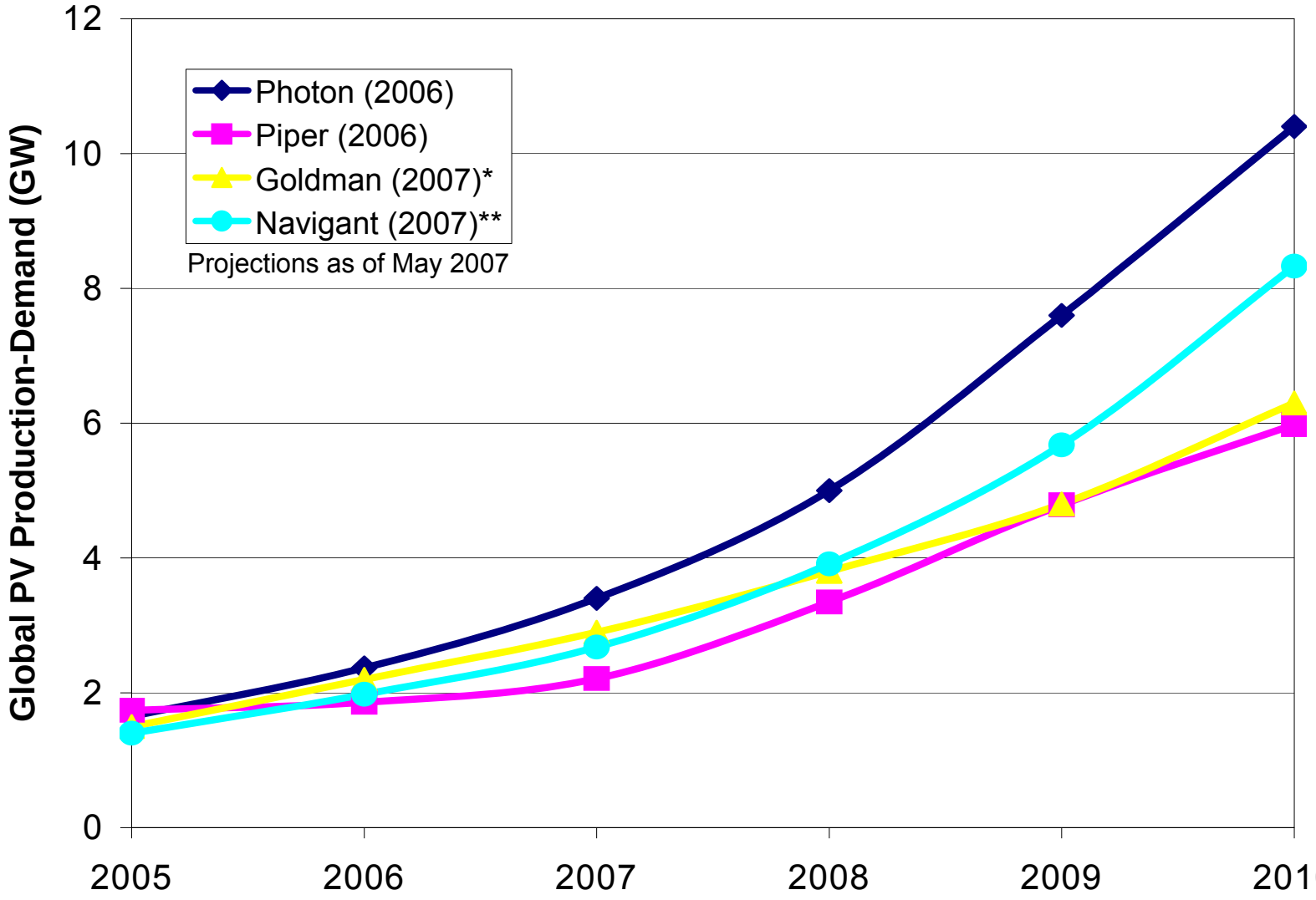


Commercial PV installations are small <500kW, but can be brought on more quickly than centralized plants



Distributed PV in particular avoids NIMBY issue and can be installed very rapidly.

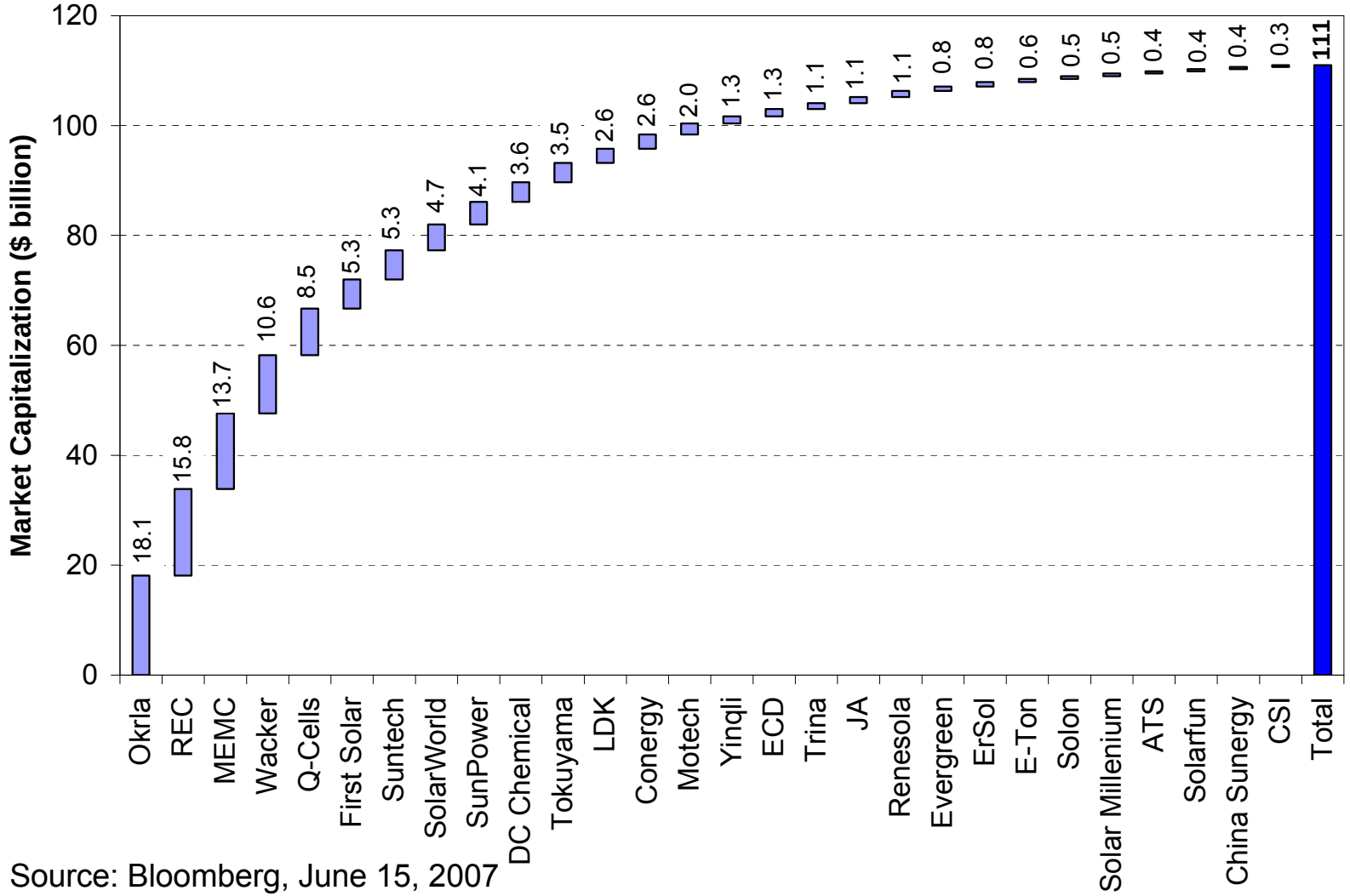
Analysts forecast rapid expansion of supply based on availability of polysilicon, thin films, and install segment



* Goldman projection is for demand

** Navigant projection is for accelerated case

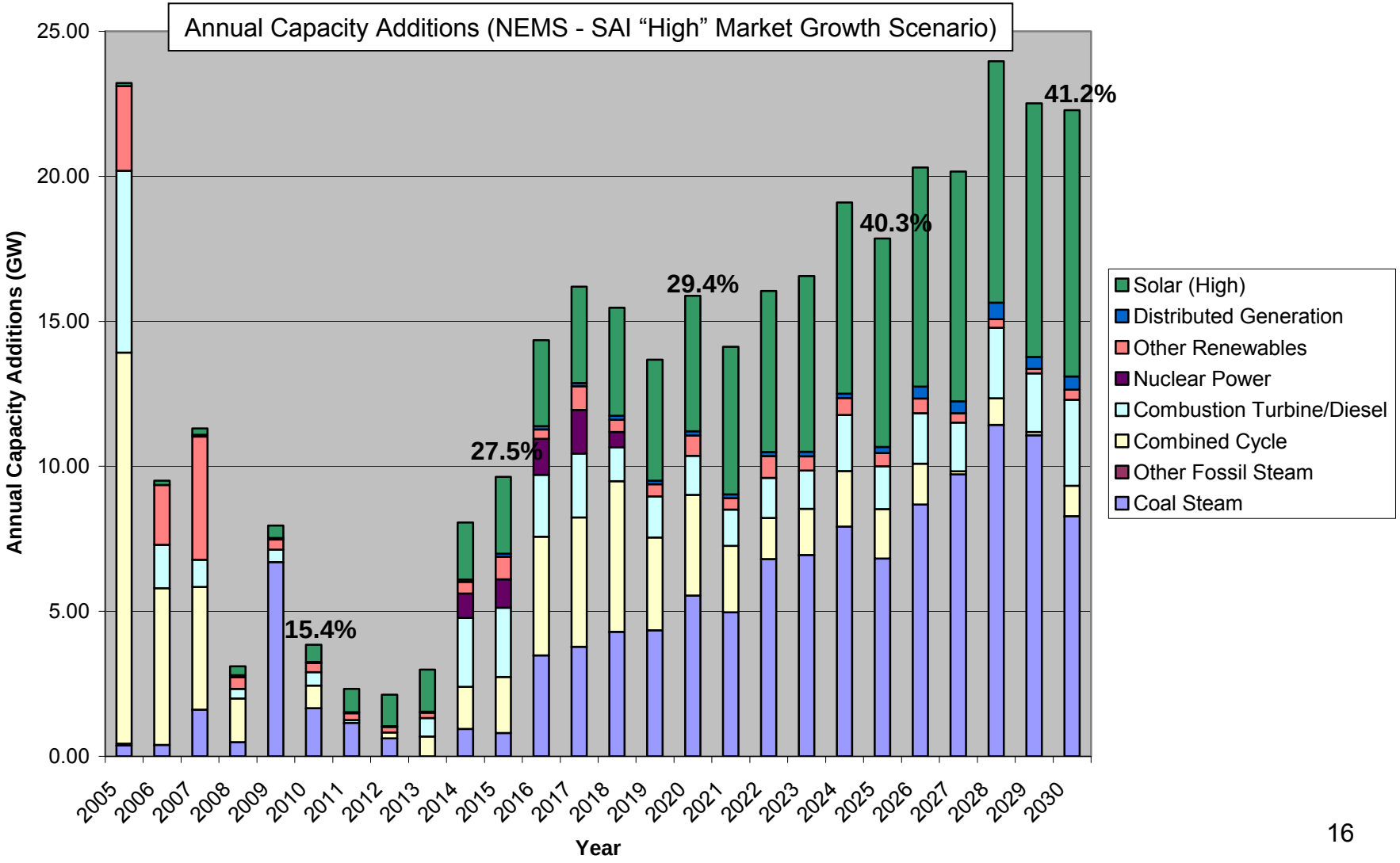
Market capitalization for PV firms now exceeds $110B, based on expectations for steep growth in supply/sales



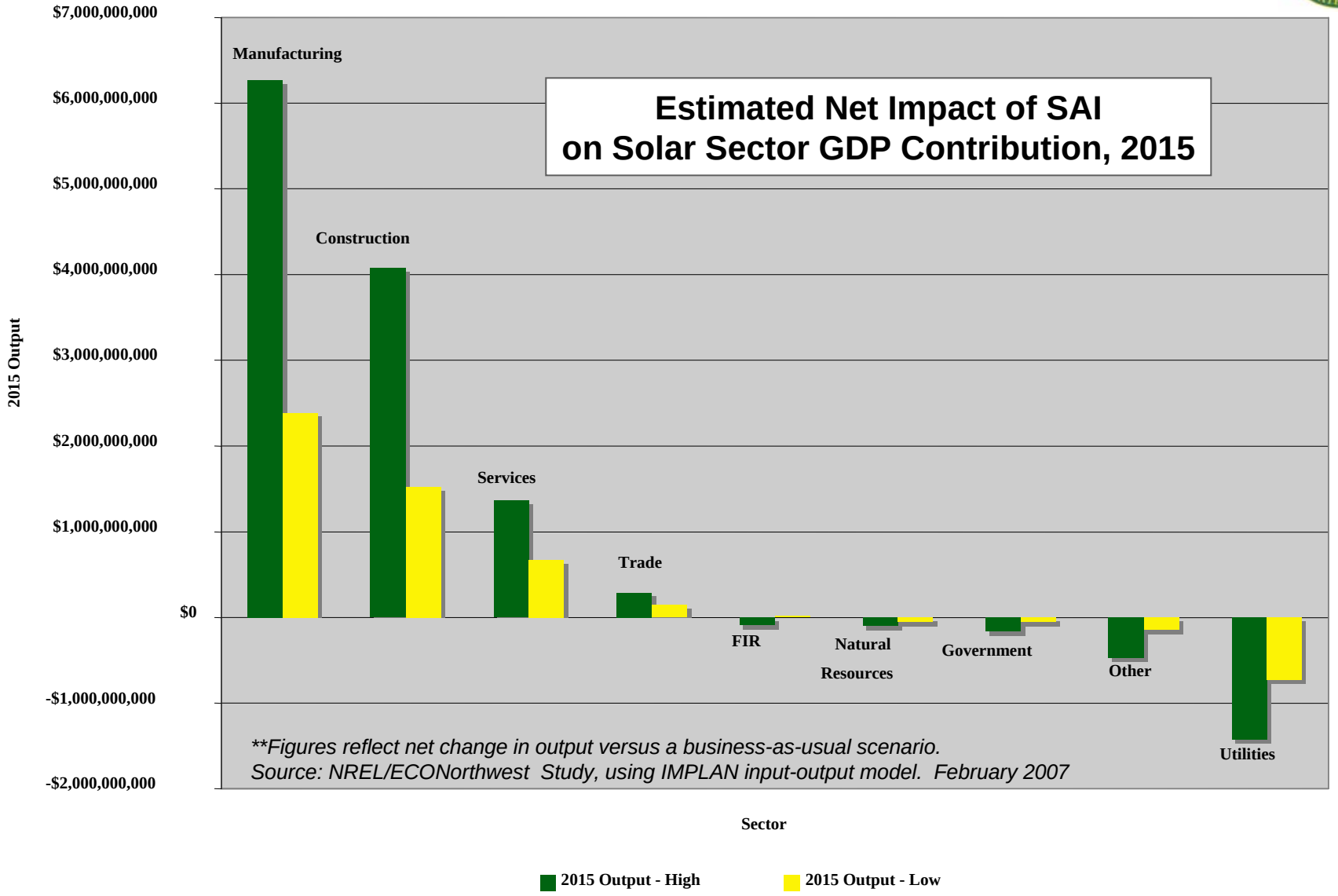
Source: Bloomberg, June 15, 2007

Pure-play PV sector market capitalization is more than $110 billion and rising.

PV has potential to capture above 30% of new electricity generating capacity additions after 2015, with higher possible especially when coupled with building efficiency

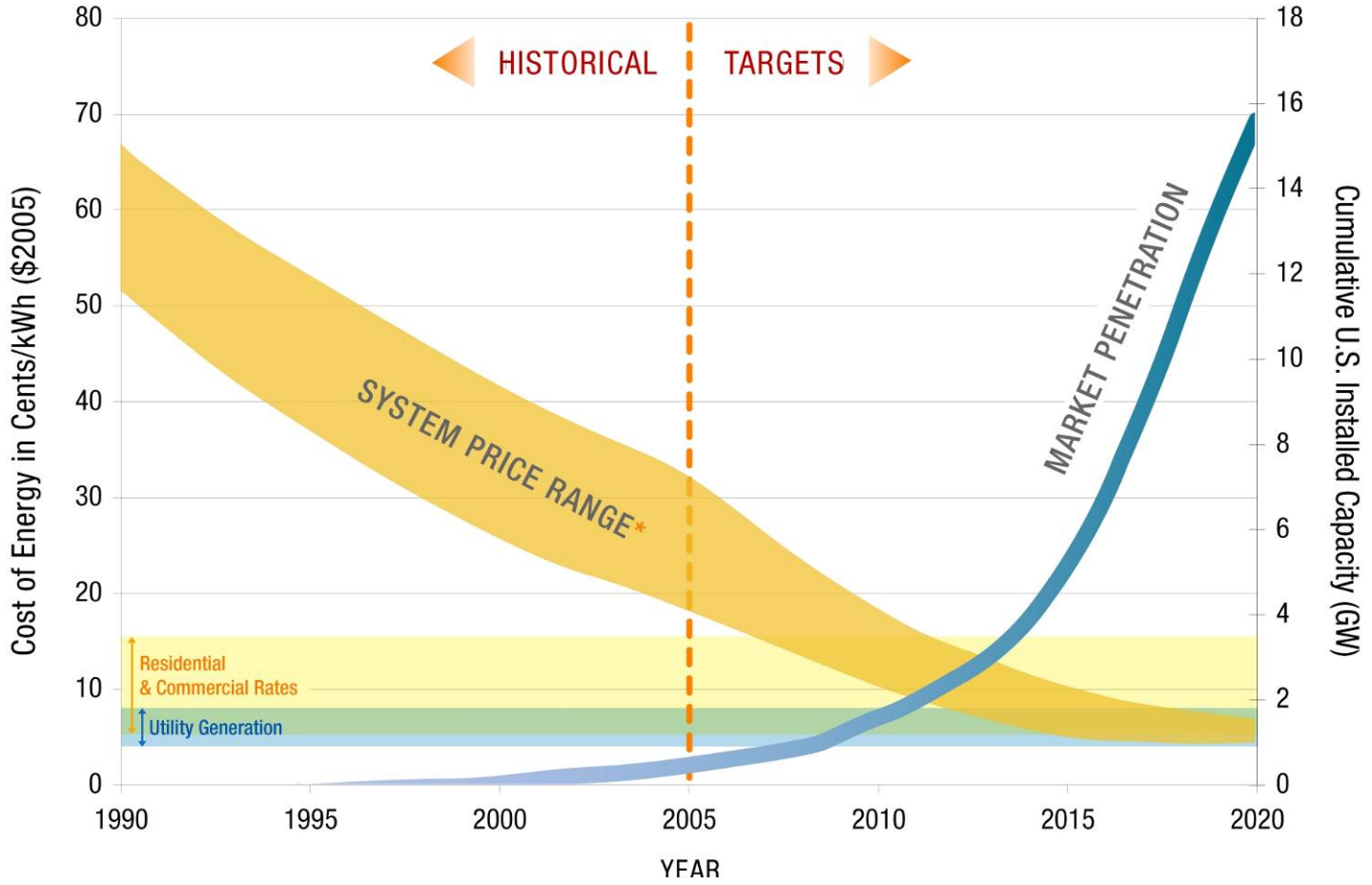


By reducing prices for PV, we will create an industry that can drive significant growth in economic output and jobs



SAI investment of $1B may result in up to $9B/YR net increase to GDP in 2015.

The goal of the President's Solar America Initiative is to make PV cost-competitive by 2015 across the U.S.



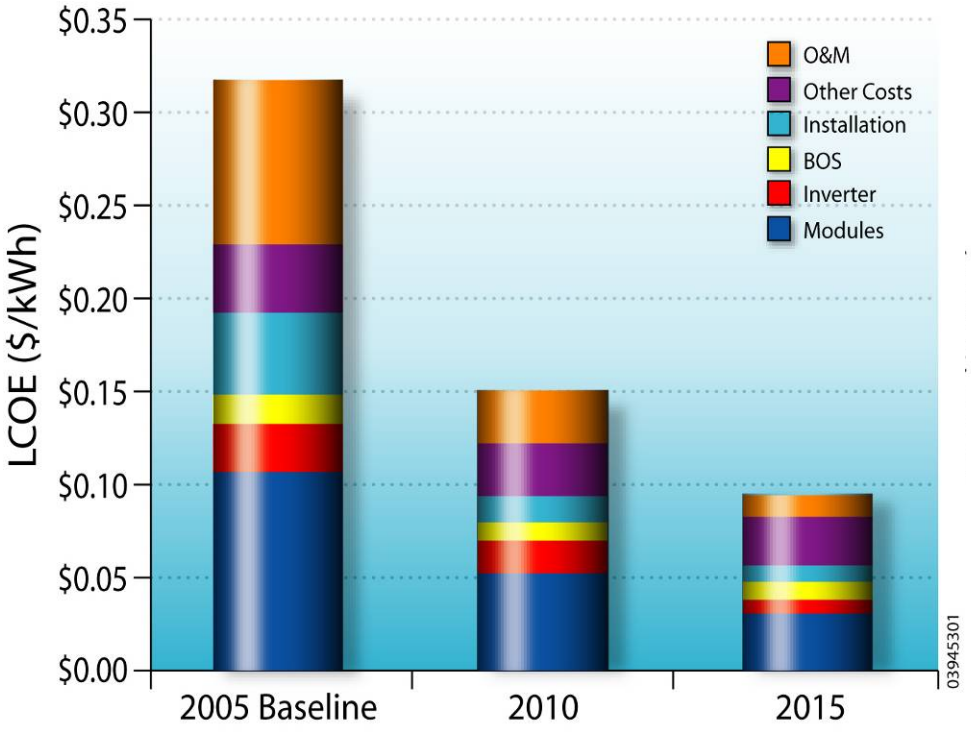
Market Sector	Current U.S. Market Price Range (¢/kWh)	Cost (¢/kWh) Benchmark 2005	Cost (¢/kWh) Target 2010	Cost (¢/kWh) Target 2015
Residential	5.8-16.7	23-32	13-18	8-10
Commercial	5.4-15.0	16-22	9-12	6-8
Utility	4.0-7.6	13-22	10-15	5-7

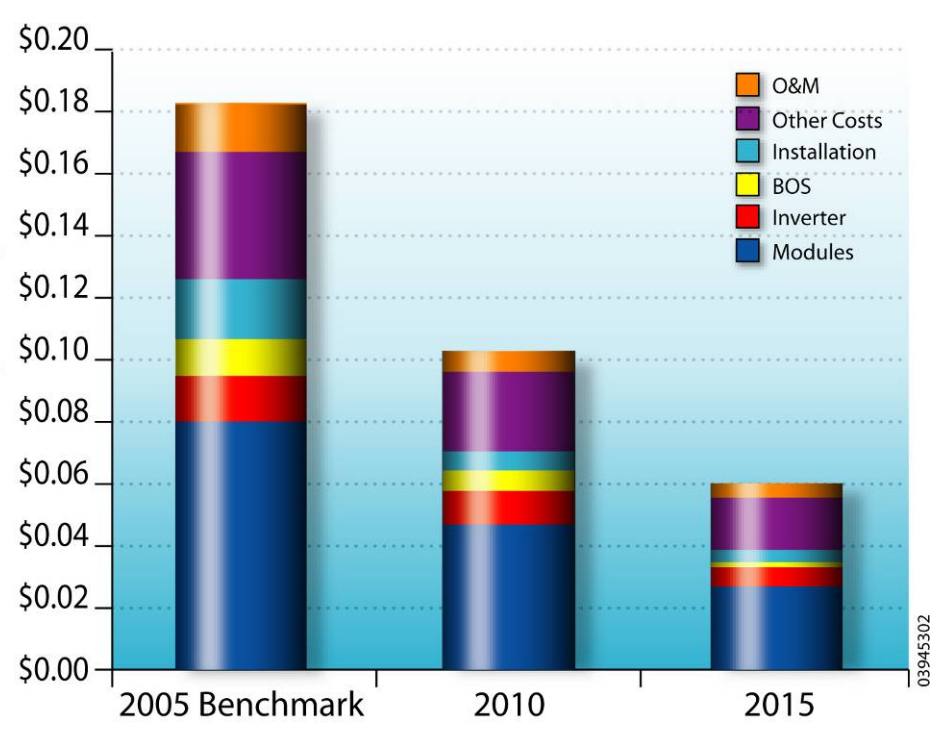
Evolution of technical performance and industry structure lead to evolution in program goals & strategy

	PRE-SAI	SAI
Research Focus	Technical improvements to individual components	Technical improvements to integrated PV systems
Performers, R&D Agenda	• National Labs drive R&D to enabling efficiency/cost requirements • Companies and universities get help maturing technology	• Companies develop products for priority market applications • Industry influences Lab/university research agenda
Program Goal Date	2020	2015
Pace of Progress	Incremental progress through stable laboratory funding	Substantial progress driven by large competitive solicitation and aggressive downselect process
R&D Funding Approach	Individual projects at National Labs, Universities, and Companies	System projects with multiple value-chain partners, Individual projects for earlier-stage technologies
Technology Acceptance	Large number of small-scale projects that generate local interest	Small number of large-scale, high-visibility projects that will help lower PV market barriers

Lab improvements to module efficiency and fabrication provided a basis for the industry product/processes that will drive the program in the future.

Achieving US grid parity will require 2-3X improvement in cost/kWh for modules/inverters – O&M, installation require even more aggressive improvements



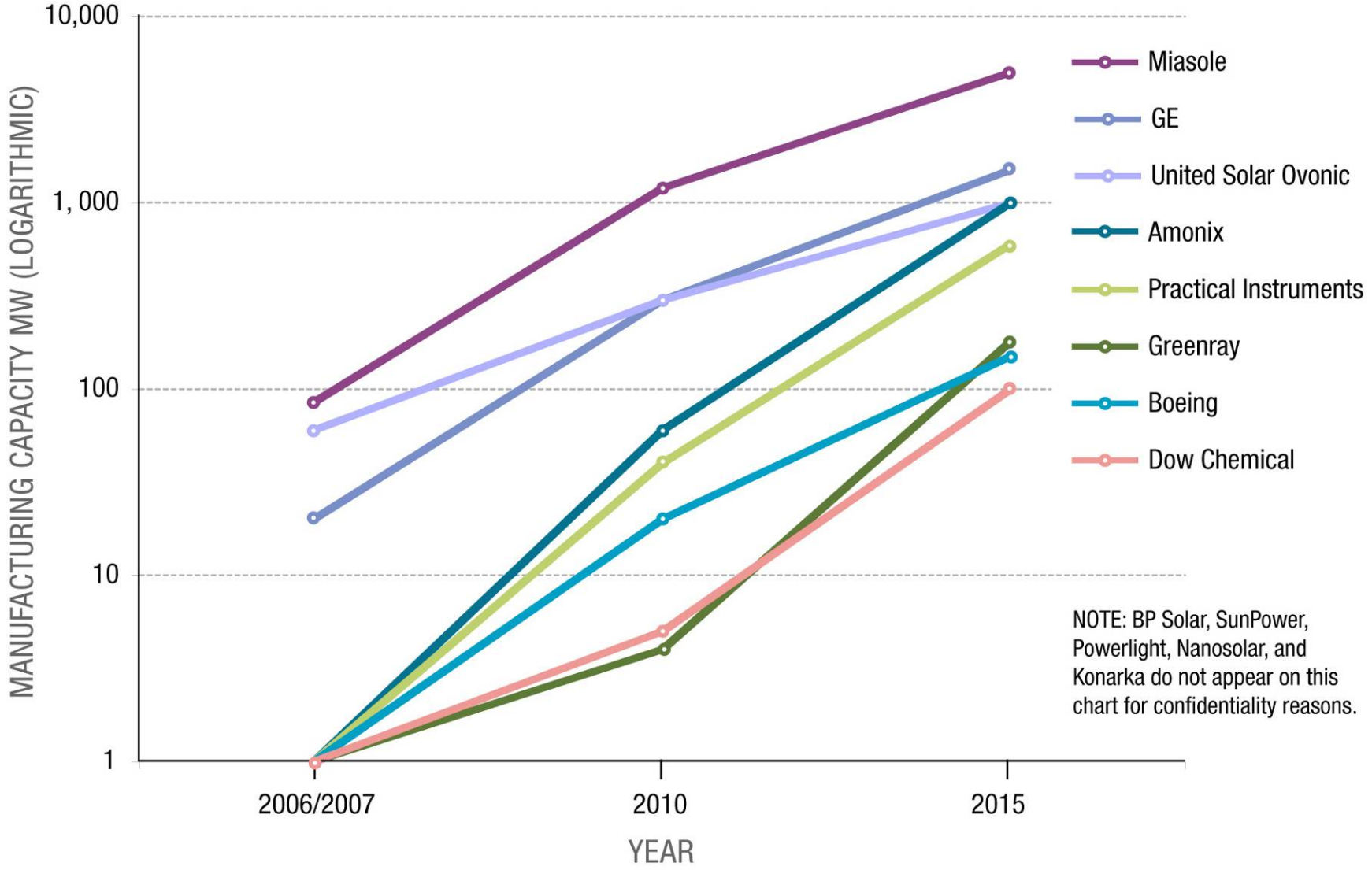


PV R&D pipeline will support technologies/companies, with funding opportunities calibrated to maturity

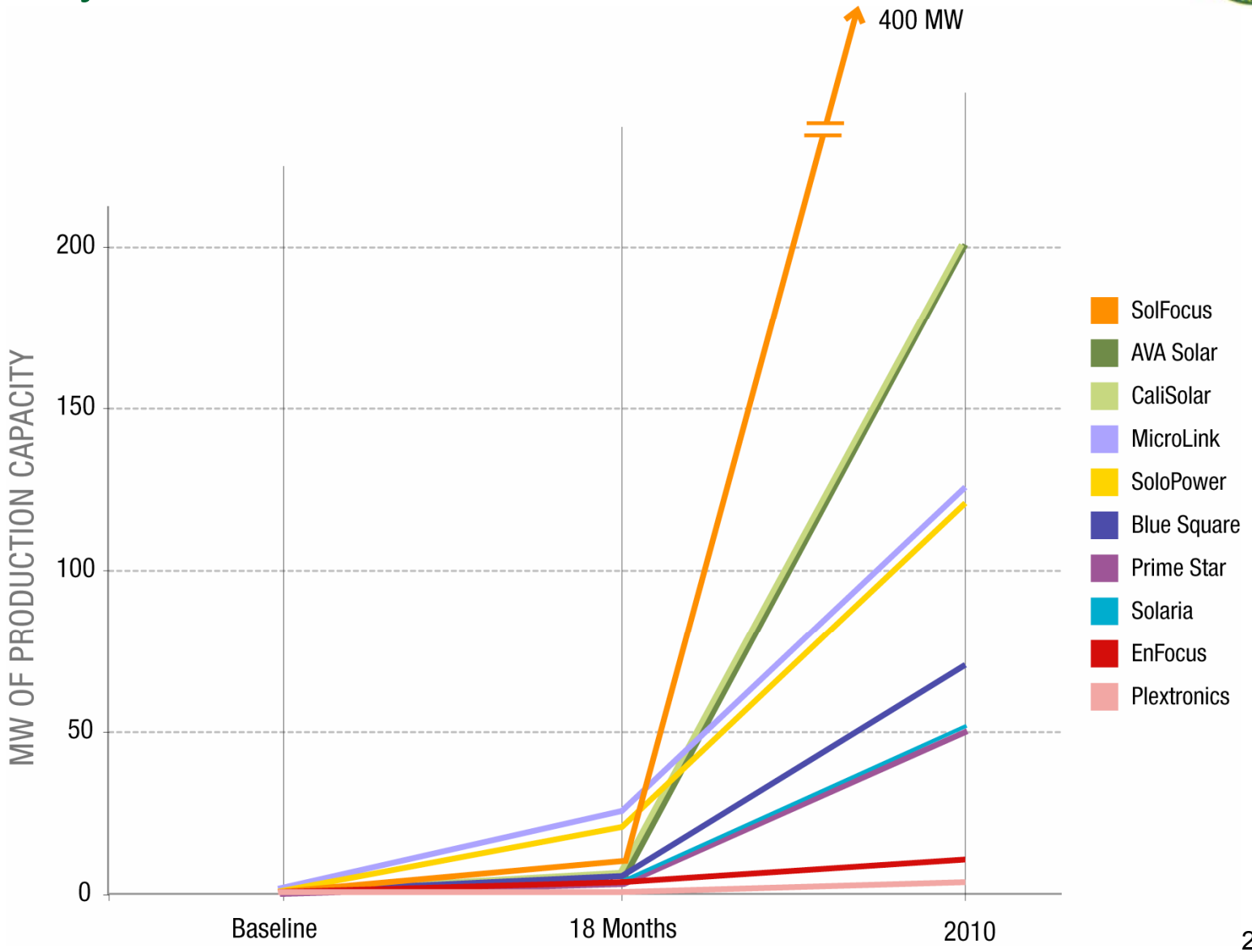
PHASES	Material & Device Concepts	Device & Process Proof of Concept	Component Prototype & Pilot Scale Production		System Development & Manufacturing	
SOLICITATION	Solar Energy Utilization	Future Generation PV Devices & Processes	PV Component / System Incubator	Advanced Inverters & Energy Management Systems	University Product & Process Development Support	Technology Pathway Partnerships
FUNDING SOURCE	DOE/O/S, BES	DOE / SETP	DOE / SETP	DOE / SETP	DOE / SETP	DOE / SETP
DESCRIPTION	New materials and pathways for solar to electric conversion	Novel devices or processes with potentially significant performance or cost advantages	Prototype PV components or systems produced at pilot-scale with demonstrated cost, reliability, or performance advantages	Design, test, and produce advanced inverters and energy management systems with improved reliability, enhanced value, and reduced costs	Universities perform targeted materials science and process engineering research in support of industry-led teams developing new PV systems for commercialization in 2010-2015	PV systems and components ready for mass production delivering energy at target costs
PROJECT LIFECYCLE	3 years	3 years	1.5 years w/ 9 mo. On/Off Ramp	3 years	3 Years	3 years
ANNUAL FUNDING LEVEL	$0.3 - 1.5 Million	≤ $300K	$1 - 2 Million	$1 - 2 Million	Up to $300,000/year	$2 - 7 Million
TEAM LEADS	Universities or Laboratories*	Businesses or Universities*	U.S. Commercial Entity	U.S. Commercial Entity	Universities	U.S. Commercial Entity
ELIGIBLE PARTICIPANTS	All	All	Universities / Laboratories*	All	Universities	Universities / Laboratories*
ENTRANCE CRITERION	Basic science properties conceived/simulated	Materials synthesized; properties observed	Coupon-scale PV cell; process demonstrated in lab; proof of concept demo	Power electronics and control system manufacturing capability	Identification of manufacturing process or component improvements possible through targeted research investigations.	Prototype components; pilot production demo; business case established
EXIT CRITERION	Materials synthesized; properties observed	Coupon-scale PV cell; process demonstrated in lab; proof of concept demo	Prototype components; pilot production demo; business case established	Pre-commercial inverters / energy management systems submitted for product certification	Incorporation of research results into commercial manufacturing operations or product designs.	Commercial PV systems and subsystems; scaled production demonstrated >25MW
TOPICS	• Single-crystal, poly-crystalline, amorphous, and nanostructured inorganic and organic materials • Electronic structure • Single or multiple junction solar cells	• New devices and structures using materials such as thin-film silicon, microcrystal-line/amorphous silicon, poly-crystalline metal chalcogenides and oxides, nanocrystal-line materials, biomimetic concepts, organic materials, photoelectrochemical cells, dye-sensitized materials, materials with low-dimensionsal quantum structures • Very-high efficiency epitaxial solar cells or other concepts	• Modules: multiple technologies (including CPV) seeking efficient material use, better performance, or improved manufacturing • BOS Components: higher reliability inverters, CPV trackers, rapid installation features, storage systems • Systems: controls and smart monitoring, integration of components, factory diagnostics	Lower cost, higher value systems resulting from: • integrated circuitries, • advanced thermal management, • advanced transient overvoltage protection, • micro-grid-ready controls, • replacement of unreliable components, • integration with storage or UPS, • compatibility with buildings applications, • communications options, • customer-friendly energy monitoring, • reduction in parts and installation steps, • standards compliance, • innovative packaging, • self diagnostics, and • incorporation of other new enabling technologies	Identifying and developing: • Fabrication processes to improve material properties during manufacture • Improved solar cell materials • Innovative device designs to improve solar cell efficiency • Simpler, lower cost manufacturing processes • New electrical contacting techniques for improved efficiency and reliability • Diagnostic techniques to identify properties and quality of solar cells materials during manufacturing • Improved materials utilization processes • Understanding of chemistry between encapsulants and solar cell materials • Providing careful long-term field testing of modules and systems in support of product improvement	• Partnerships with U.S. industry for projects that focus on development, testing, demonstration, validation, and interconnection of new PV components, systems, and manufacturing equipment • Technology improvements in PV system and component design, integration, and installation will be a focus • Cost reductions, performance enhancements, and reliability improvements are sought for all aspects of PV systems

NOTE: The NREL and SNL teams that are part of the SETP program will continue to provide technical support for these activities through the SETP but will not be direct participants

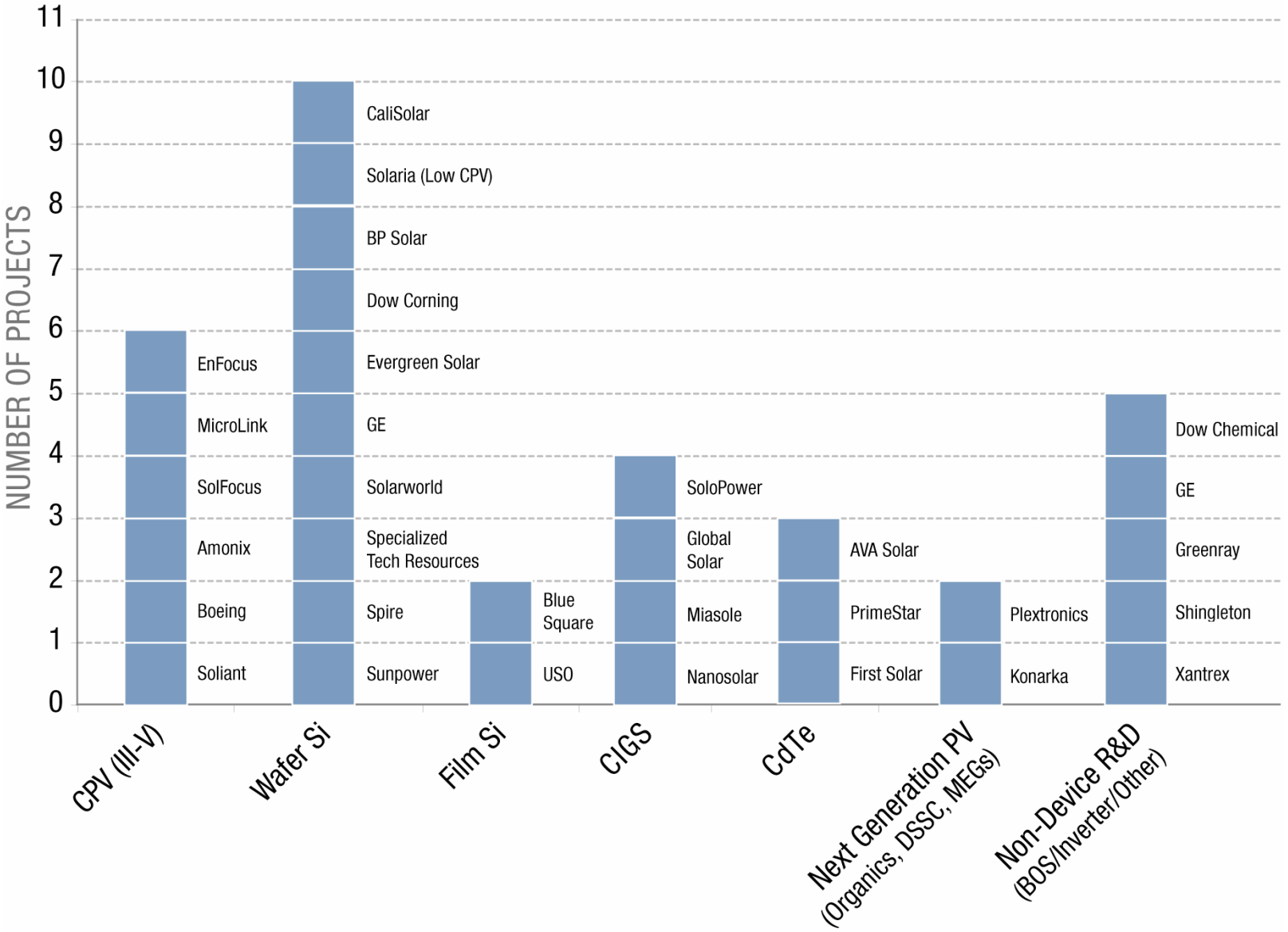
TPP Projects Will Develop Scale-able Manufacturing Processes, for Commercial Ramp in 2010-2015



Incubator Projects Will Quickly Ramp Production Capacity to Pilot and Commercial Levels



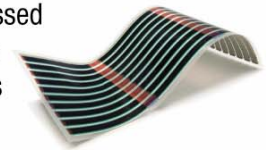
DOE's Portfolio Balances Technology, Maturity & Risk, with new early-stage companies adding diversity



FY07 National Lab module research balances various materials thru joint industry R&D and long-term research

4% Organic PV

Customizing organic molecules for optimal cell efficiency in materials that can be processed without expensive vacuum chambers



1% Dye Sensitized Cells

Advancing the efficiency and stability of inexpensive dye-based solar cells with novel nanostructures

22% Wafer Silicon

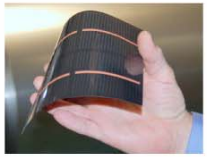
Combining thin amorphous and wafer silicon to make high efficiency cells with smaller total amounts of silicon

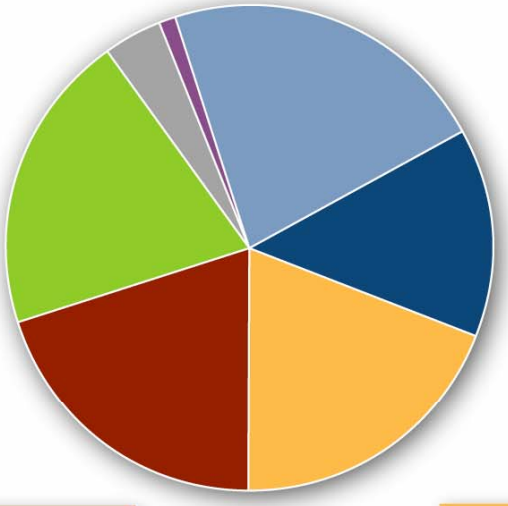
Developing new ink-jet printing methods for silicon electrical contacts

20% Thin Films (CIGS)

Supporting the novel manufacture of CIGS cells from ink-based precursors

Transferring discovery that highest performance material has nanostructured patterns into a fast and uniform manufacturing process

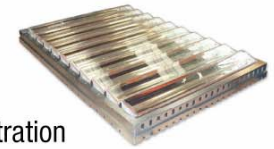




14% Concentrator PV

Devising strategies for making quicker, easier, less precise cells but maintaining record performance

Achieving record efficiencies (33.8%) even without concentration



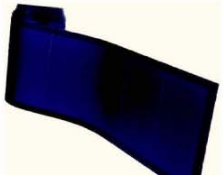
20% Thin Films (CdTe)

Produced thinner films with same cell performance

Discovered a more durable way to make electrical contacts

19% Thin Films (Silicon)

Developing methods of making thin silicon film solar cells on inexpensive glass and at low processing temperatures

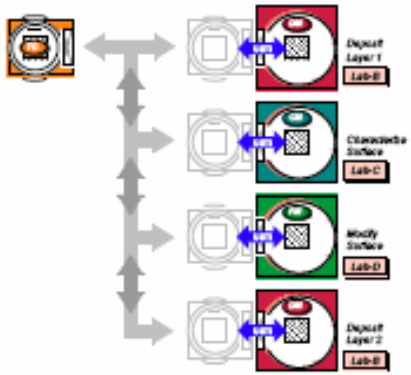


FY07 National Lab program also provides testing & evaluation and manufacturing process development

Systems Analysis

- Advancing whole-system testing and analysis protocols
- Developing improved inverter performance models, including long-term degradation
- Investigating wireless irradiance and temperature sensing monitors and "smart" diagnostics
- Working with Xcel (a Colorado utility) to conduct grid integration studies
- Enhanced Solar Advisor Model, which is used to calculate performance and financial parameters of solar systems, by adding federal and state incentive tools among other improvements

Process Development Integration Lab

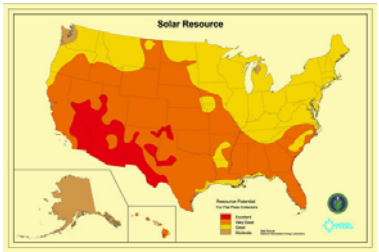


- Acquired the first PDILPlatform (Silicon), which will allow industry and lab personnel to integrate and test deposition, processing, and characterization tools
- Designed and ordered Platforms for CIGS, Atmospheric Processing, Electro-optic Characterization
- Also invested in a silicon crystal growth furnace for testing solar cell feedstock

Reliability Testing

- Aging modules through accelerated exposure, first Si and a-Si, then Cd Te and CIGS
- Developed an improved strength and durability testing technique applicable to many PV module types
- Added new equipment to simulate a variety of environmental conditions
- Reaccredited for both cell and module measurement services (one of two labs in world with both accreditations)

Solar Resource Assessment



- Completed development of National Solar Radiation Database Update with hourly irradiance and surface meteorological data for 1,454 stations in the U.S

Industry, University, and Lab R&D will focus on highest-potential approaches to cost/performance improvement

Crystalline Silicon Modules

- Improve silicon utilization and use new silicon production methods
- Increase module efficiency thru new cell designs
- Increase manufacturing throughput thru automation
- Develop new module designs for that reduce installation costs

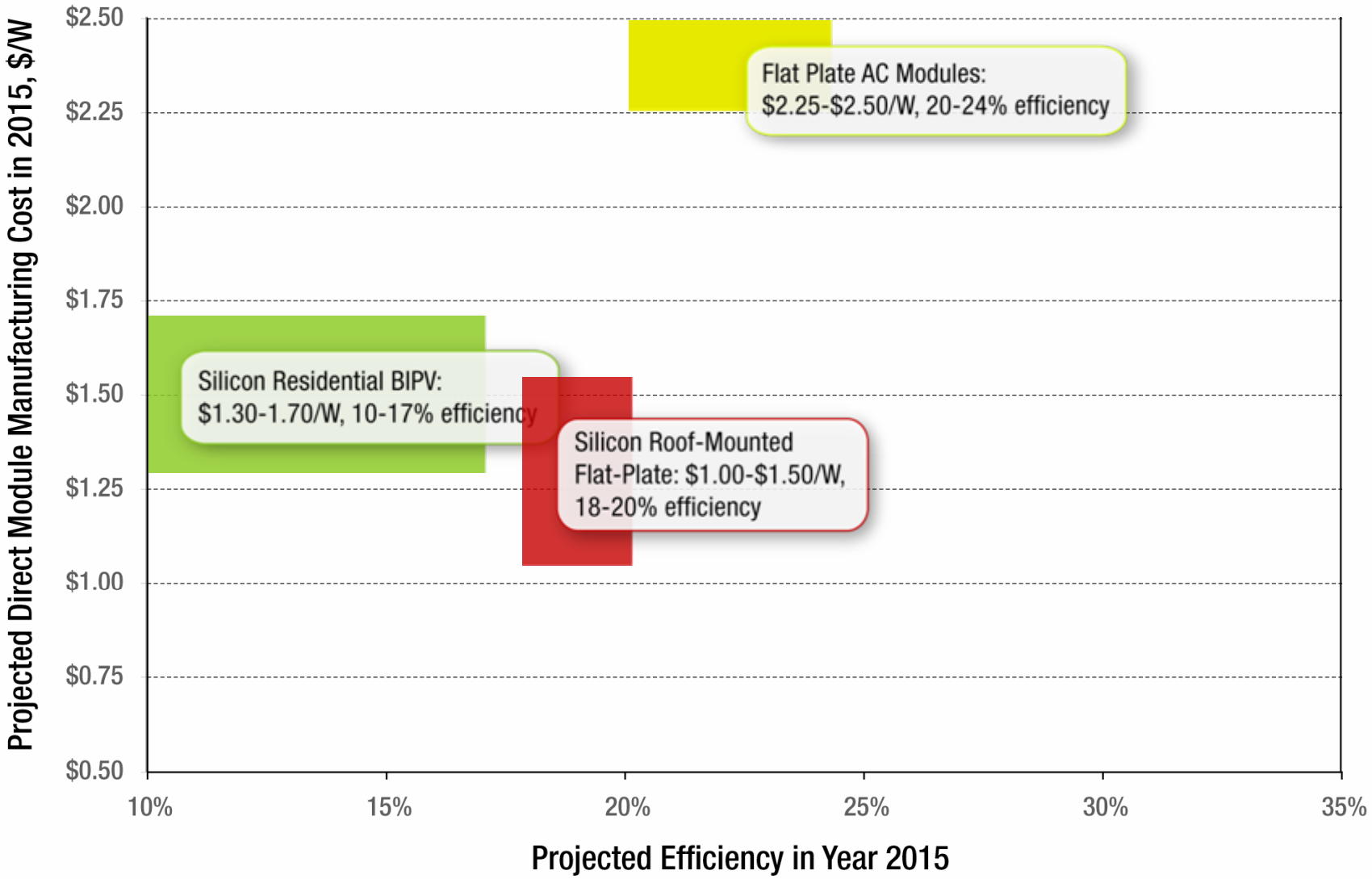
Thin Film Modules

- Demo & scale-up new fabrication processes (sputtering, printing)
- Increase efficiency of modules to >10% with higher yields
- Integrate process steps to realize low capital expenditure potential
- Extend reliability thru improved encapsulants and accelerated tests

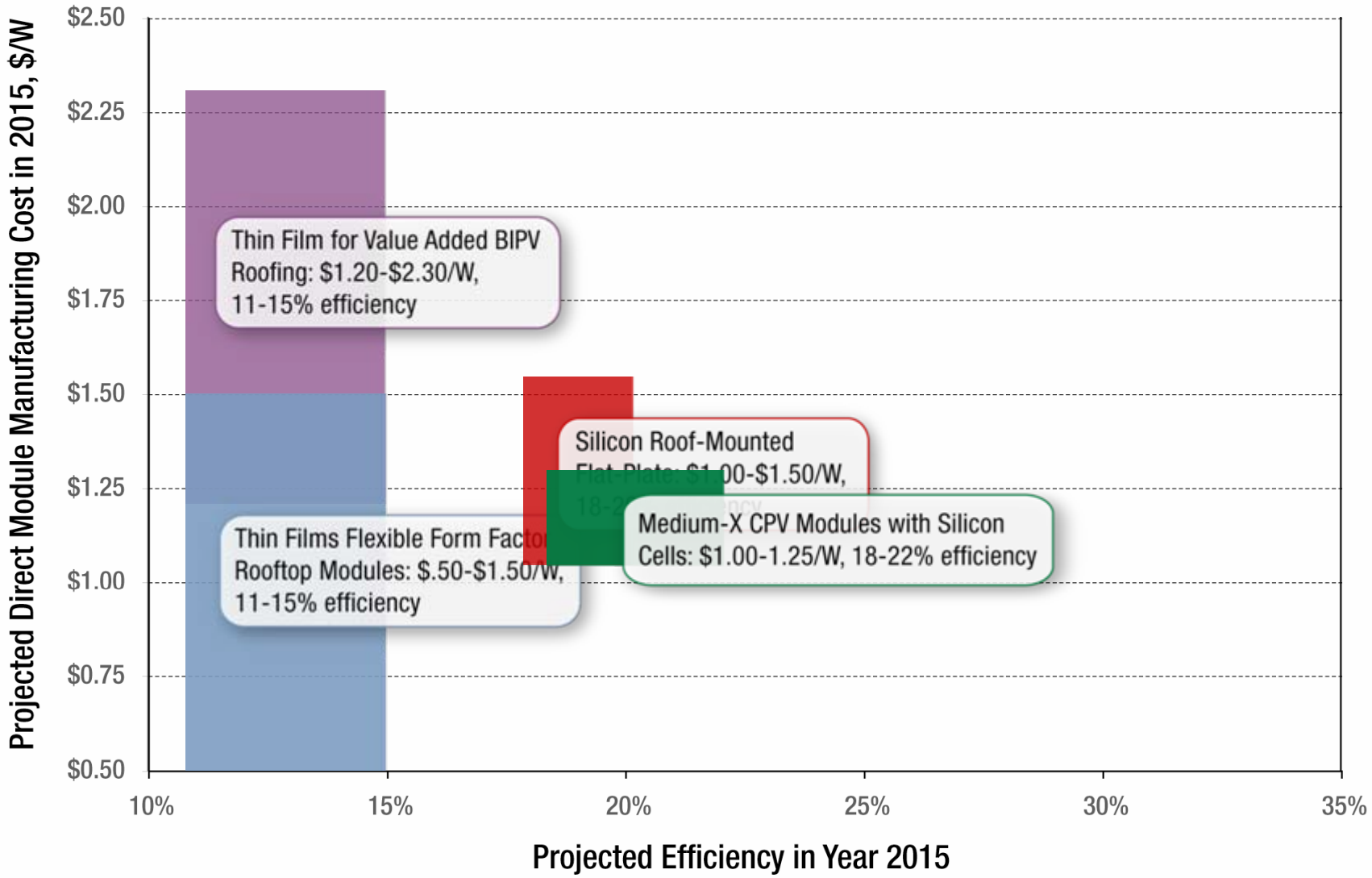
Balance of System Components & Installation

- Increase inverter lifetime to 15 years and improve quality control
- Develop utility-interactive controls & building energy management systems
- Optimize system designs for “plug & play” and/or fast installation

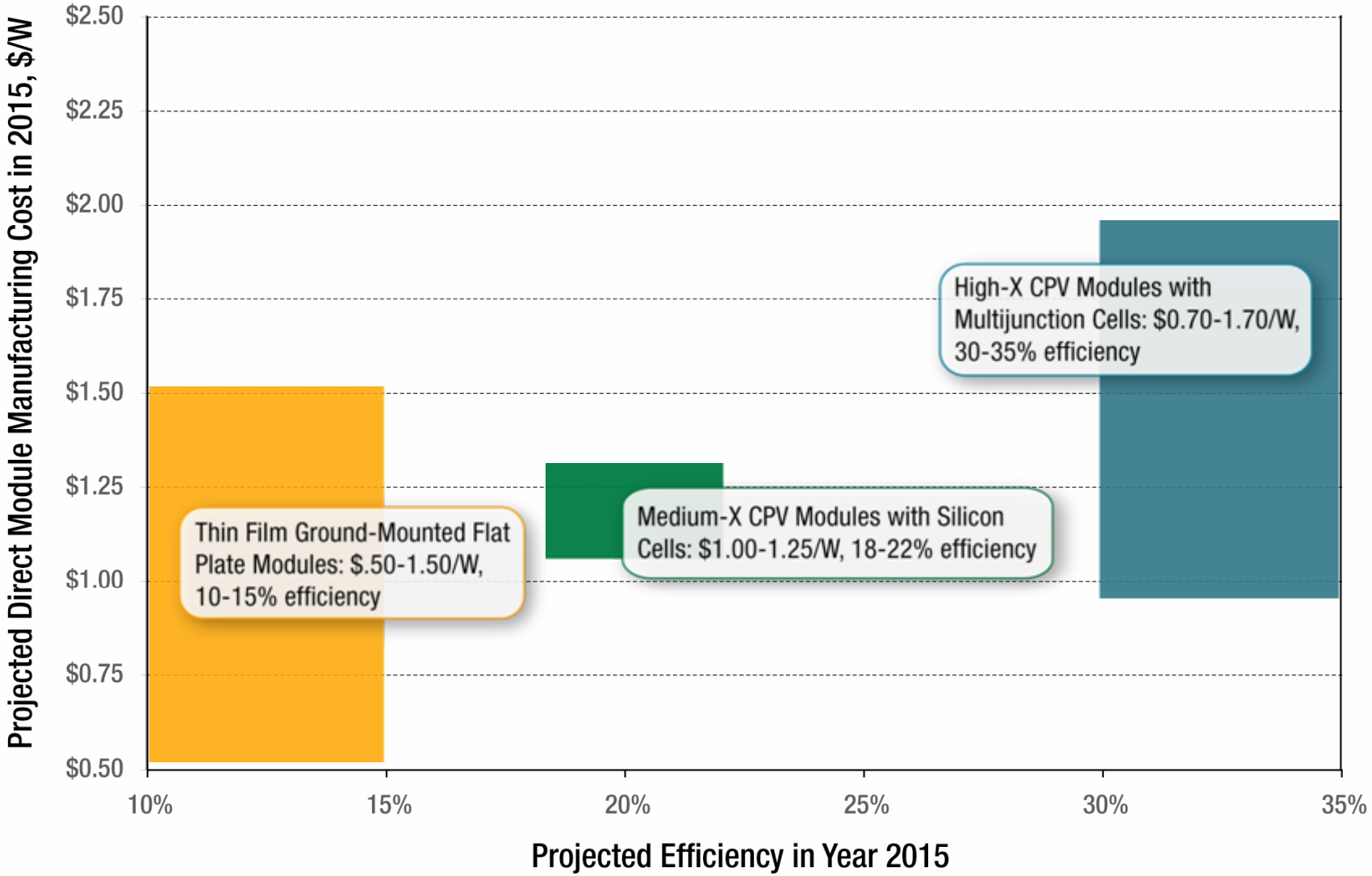
Area-constrained residential applications will require high efficiencies, but value-add can accommodate higher $/W



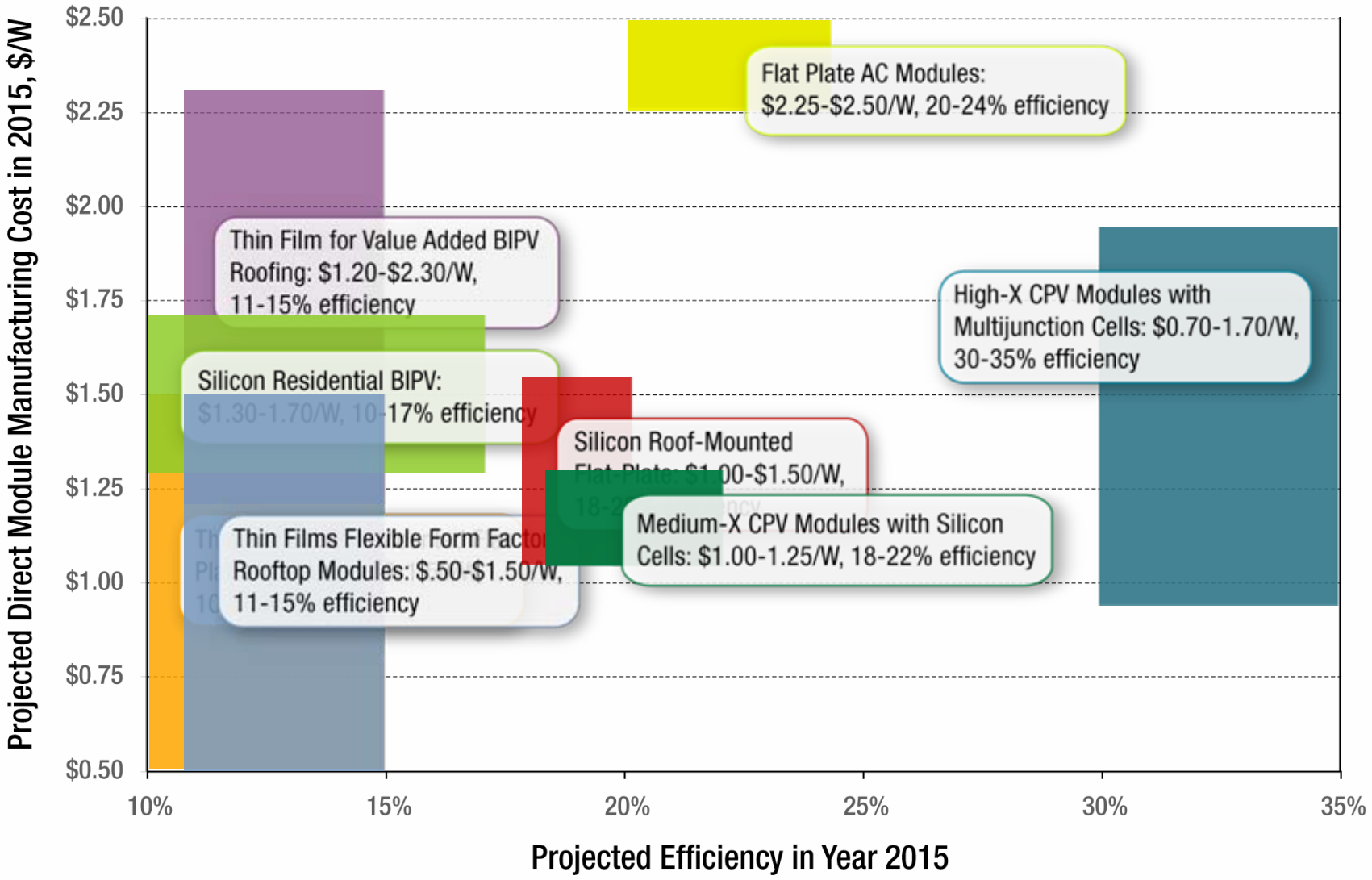
Commercial app's may accept lower efficiencies if $/W is lower and if form factor/BIPV reduce installation cost; c-Si and med-X CPV will play to customers seeking max kWh's



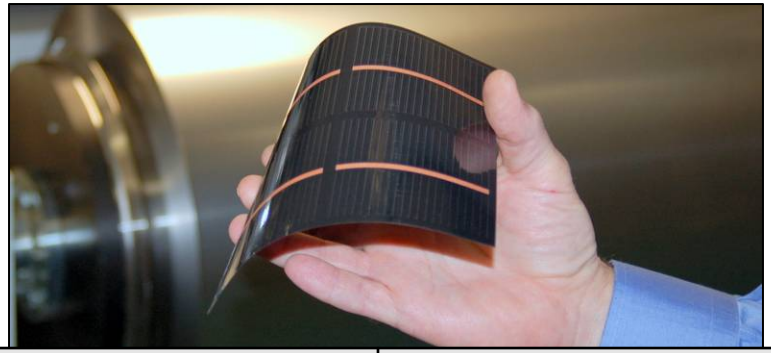
No consensus requirements for U.S. utilities yet – CPV seeing strongest interest but European-like flat plate TF module approach may play in certain circumstances



DOE will drive its R&D agenda towards optimal solutions for major markets – while consensus remains unclear, investors should focus on application fit/advantages



CIGS R&D Roadmap



Parameter	Present Status (2007)	Future Goal (2015)	Approach
Champion device efficiency	19.5%	21-23%	Defect analysis and device physics
Commercial module efficiency	5%-11%	10%-15%	Characterization and improved processes
Module cost ($/$W_p$)	Not established, estimated <$2/$W_p$	≈$1/$W_p$	Thinner absorbing layers, increased yield
$/Watt installed cost	$5-12/Wp	$3/$W_p$	Novel flexible module designs
LCOE	20 - 40 c/kWh	7-10 c/kWh	Reliability, performance
Overall Process Yield	Not available	>95%	Uniformity and control
Reliability metric	Pass crucial steps of test protocol, e.g., damp heat	Verify that guaranteed long-term power levels will be met	Establish accelerated aging tests and improved encapsulation.
Deposition rate high η cell	5 μ/h	30 – 40 μ/h	Lower temp. processes
Thin (<0.7 μ-thick CIGS or alternative cells)	>80% of respective champion efficiency values	≈100% of respective champion efficiency values	Enhanced optical design, alternative device schemes

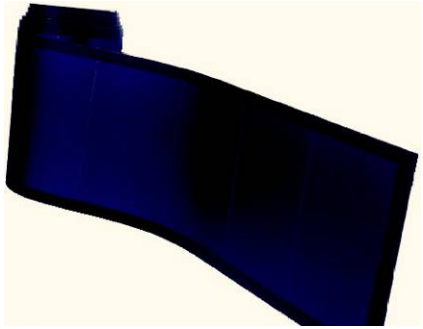
CdTe R&D Roadmap

Parameter	Present Status (2007)	Future Goal (2015)	Approach
Champion device efficiency	16.5%	18%-20%	Improved modeling and device understanding
Commercial module efficiency	>9%	13%	Controlled carrier concentrations and improved back-contacts
Module cost ($/W)	1.25	0.70	Maturing deposition techniques/alternative absorber layer processes
$/Watt installed system cost	$4-5/W	$2/W	Enlarged and simplified module designs
LCOE	0.18-0.22 ¢/kWh	0.07-0.08 ¢/kWh	Scale up production
Overall process yield	80%	95%	Improved control of high rate depositions
Identify relevant degradation mechanisms	1.2% per year	0.75% per year	Develop appropriate accelerated lifetime testing for device and mini-modules metric

Concentrating PV R&D Roadmap

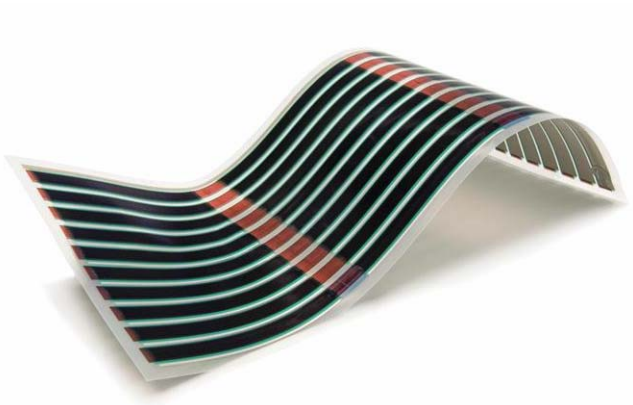
Parameter	Present Status (2007)	Future Goal (2015)	Approach
Champion device efficiency	40.7%	44%	Improved metamorphic junction architecture
Commercial device efficiency	33%-37% (III-V) 25% (Si)	36%-40%	Optimize thermal and spectral packaging of III-V
Optical efficiency	75%-85%	80%-90%	Increase acceptance angle and improved design
Commercial System efficiency	17%	29%-33%	Optimized module design and cell packaging
kWh/kW/year	Not available	2200 kWh/kW/year	Improved Tracking
Cell cost $/cm^2	$10-15/cm^2	$3-5/cm^2	Automated manufacturing
$/Watt installed cost	$5-7/W	$3-5/W	Economics of Scale
¢/kWh	33-28¢/kWh	7-8 ¢/kWh	Automated, scaled-up manufacturing

Amorphous Si R&D Roadmap



Parameter	Present Status (2007)	Future Goal (2020)	Approach
Production volume	100 MW/yr	2-3 GW/yr	Increased Deposition Rates
Capital equipment cost	$2/W capacity	$0.7/W capacity	Economies of Scale
Substrate cost	$15-20/m^2	$4/m^2	Explore alternative substrate materials / improved area utilization
Module manufacturing cost for a-Si	$125 - 200/m^2	$0.70/W or $77/m^2 (11% efficiency)	Higher throughput, reduced encapsulation costs
Stabalized Efficiency, best a-Si lab cells	13%	15%	Stability efficiency improvements of individual layer
Stabalized Efficiency, commercial a-Si modules	5 - 8%	11%	Correlation between processing techniques and stabilization
Reliability of a-Si panels	20 - 25 year warranty	25 - 30 year warranty	Improved interconnections and encapsulation

Organic PV R&D Roadmap



Parameter	Present Status (2007)	Future Goal (2020)	Approach
Champion device efficiency	5.2%	12%	Identify candidate materials whose fundamental properties, such as optical absorption, band structure, carrier mobility that allow for high theoretically attainable efficiencies.
Cell degradation	< 5% per 1000 hours, research-scale	< 2% per 1000 hours, module	Fundamental device analysis including photo-oxidation, interfacial instability and delamination, interdiffusion, and morphology changes

Concentrating Solar Power Technologies

A Potentially Dominant Source for Utility-Scale Power in the Southwest

Aggressive R&D and CSP project development could displace most new fossil fuel plants in Southwest U.S.

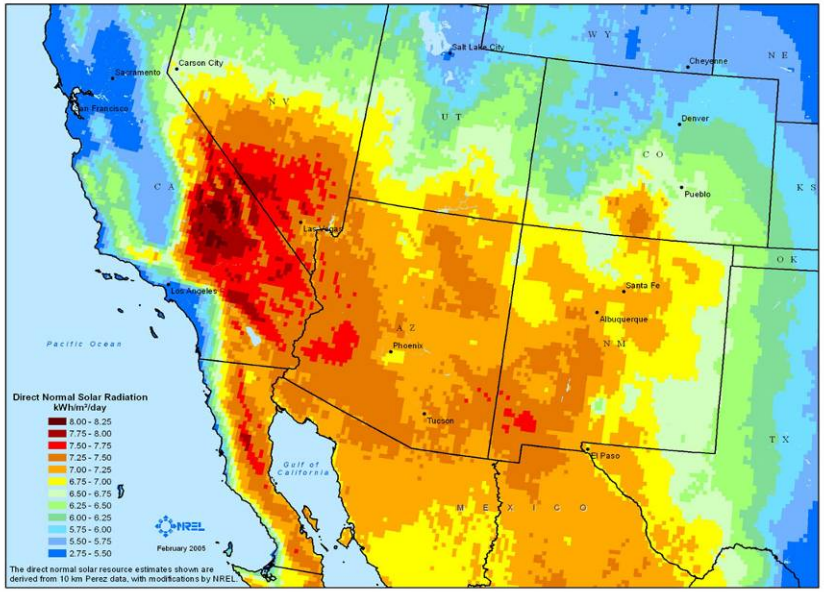
Untapped Generating Potential

- Solar energy in seven southwestern states – AZ, CA, CO, NV, NM, TX and UT – could generate more than 6X current U.S. electricity needs
  - Solar resource for 6,800 GW of versus current nation-wide capacity of approx. 1,000 GW

Significant Population Growth Centers

- 15 of the 20 fastest-growing metro areas in the country are in close proximity to solar resource
- By 2030, an estimated 41 million additional people will move to the Western United States (from 90 million in 2000 to 131 million people)

Direct-Normal Solar Resource for the Southwest U.S.



Potential Solar Generation Capacity by State

State	Land Area (mi²)	Capacity (GW)	Generation (GWh)
AZ	19,279	2,468	5,836,517
CA	6,853	877	2,074,763
CO	2,124	272	643,105
NV	5,589	715	1,692,154
NM	15,156	1,940	4,588,417
TX	1,162	149	351,774
UT	3,564	456	1,078,879
Total	53,727	6,877	16,265,611

RPS requirements are driving numerous solicitations for renewable power including CSP

U.S. projects: enabled by 30% investment tax credit and State renewable portfolio standards

State	RPS Requirement
Arizona	15% by 2025
California*	20% by 2010
Colorado	20% by 2020
Nevada	20% by 2015, 5% Solar
New Mexico	20% by 2015
Texas	5,880MW (~4.2%) by 2015

* California electricity peak demand is predicted to grow from 57 GW in 2006 to 67 GW in 2016

Spanish goal: 500 MW by 2010 using 0.21 Euro/kWh feed-in tariff (as many as a dozen 50 MW plants may be in development – storage important part of projects)

Utility	Amount Desired from Solicitation (MWh)	Recent Request for Renewable Projects – Due Date and Target
Los Angeles Dept of Water and Power	2,200 GWh	4/10/07 – 20% renewable target by 2010 (now at 6%)
Sacramento Municipal Utility District		6/11/07 – 23% renewable target by 2011
Southern Cal Edison	1 MW minimum projects	5/18/07 – 20% renewable target by 2010 (now at 16-17%)
San Diego Gas & Electric	1 MW minimum projects	5/30/07 – 20% renewable by 2010
Pacific Gas & Electric	750,000 to 1,500,000 MWhs/yr	6/31/07 – 20% renewable target by 2010 (now at 12%)
Arizona Public Service (APS)	20,000 MWh minimum annual per project	5/15/07 - 125,000 MWh target in 2007, 736,000 MWh in 2011

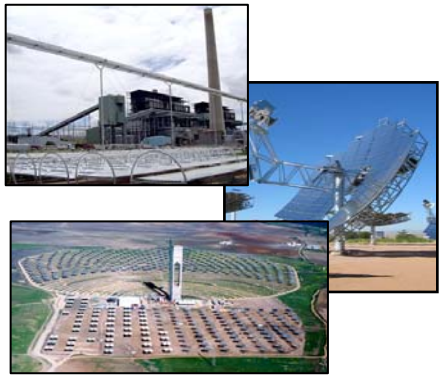
CSP R&D strategy focuses on scale-up of trough plants with storage, and demonstration of new plant designs

Troughs

- Optimize receiver and concentrator designs
- Develop next-generation collector designs and supply chain
- Scale-up plant size and increase operating temperatures

Advanced Concepts (CLFR, Towers, Dish-Stirling)

- Test new CLFR concepts in a power plant configuration
- Demonstrate new Tower plant designs to evaluate costs
- Address Dish manufacturability and Stirling engine reliability issues



Storage

- Develop advanced heat transfer fluids for more efficient operation at high temperatures with molten salt
- Test innovative designs for low-cost storage options, including thermocline tanks and new fluids for fields

CSP program aims for GW-scale intermediate load power plants by 2015, with early focus on trough designs

Near-Term Work & Savings:

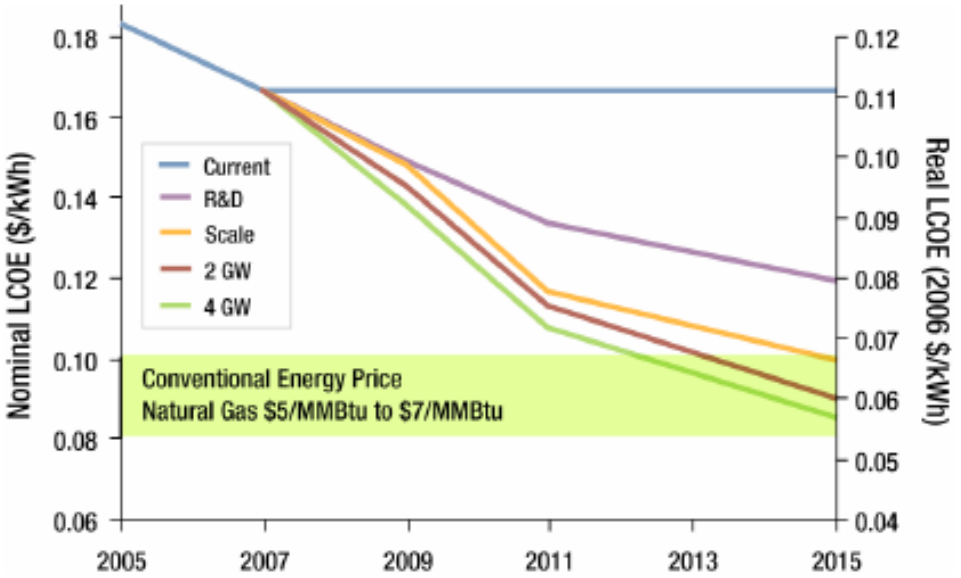
1. Plant Size (50 → 200 MW): 1 ¢/kWh
2. Tax Policy @ 30% ITC: 2 ¢/kWh

Future Work & Savings:

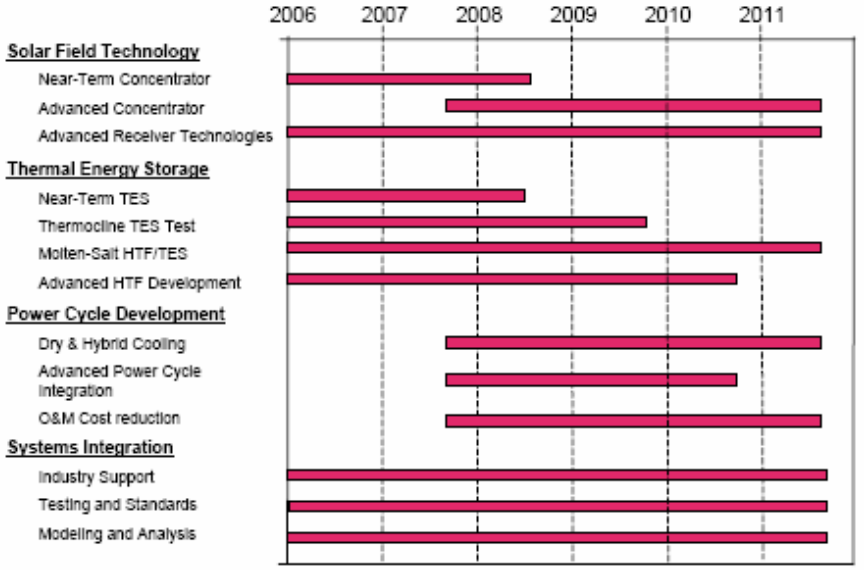
1. R&D Advances: 4.7 ¢/kWh
2. Deployment Learning: 1.0-1.5 ¢/kWh

Targets for Market Competitiveness:

1. System cost **5-6 ¢/kWh** w/o 30% ITC
2. Baseload power @ 60-70% cap factor



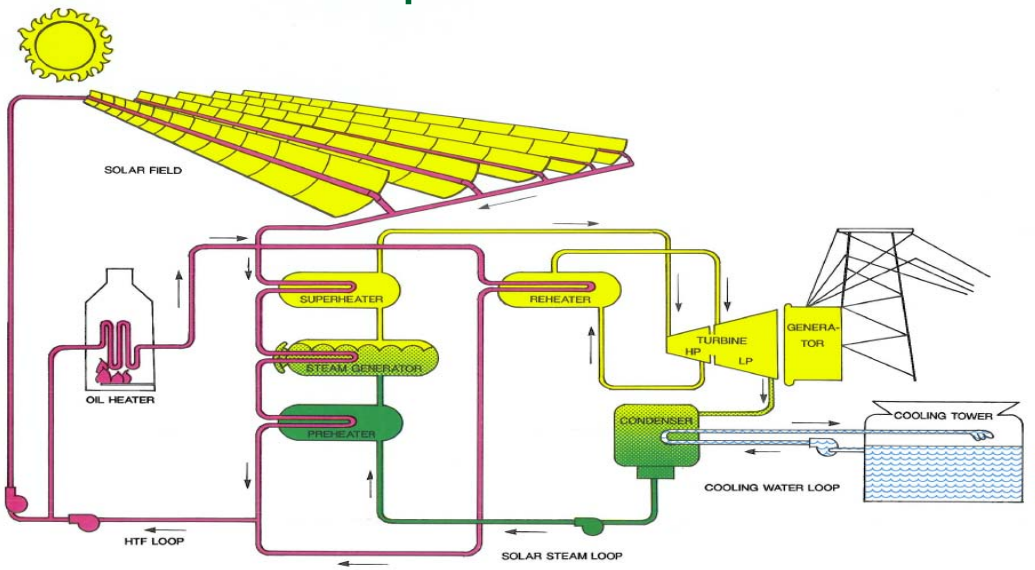
CSP Trough Milestones	Due Date
Demonstrate thermocline TES system at 1-MWe APS plant	2008
Report on Annual efficiency of Nevada Solar One	2008
High Efficiency Trough Solar America Initiative	2008
Demonstrate field performance of advanced trough receiver with overall thermal efficiency grater than 82%	2009
Demonstrate field performance of advanced trough receiver with overall thermal efficiency greater than 82%	2009
Begin operation of molten-salt test loop	2009
Field demonstrate advanced trough collector with overall optical efficiency (concentrator and receiver) greater than 70%	2010
Field validate direct thermal storage technology at a cost of $20/kWh	2011
Complete all LCOE calculations supporting TPP progress evaluations and submit for stage gate evaluations	Yearly



CSP plants must be scaled larger, with higher efficiency and lower-cost components from volume production

CSP System Attributes:

- Dispatchable power with thermal storage
- Basic materials: concrete, steel, glass
- Standard utility power block/turbine
- Quickly constructed (2 – 4 years)
- Modular design (50 – 100 MW)
- Optimal size: 100 – 250 MW



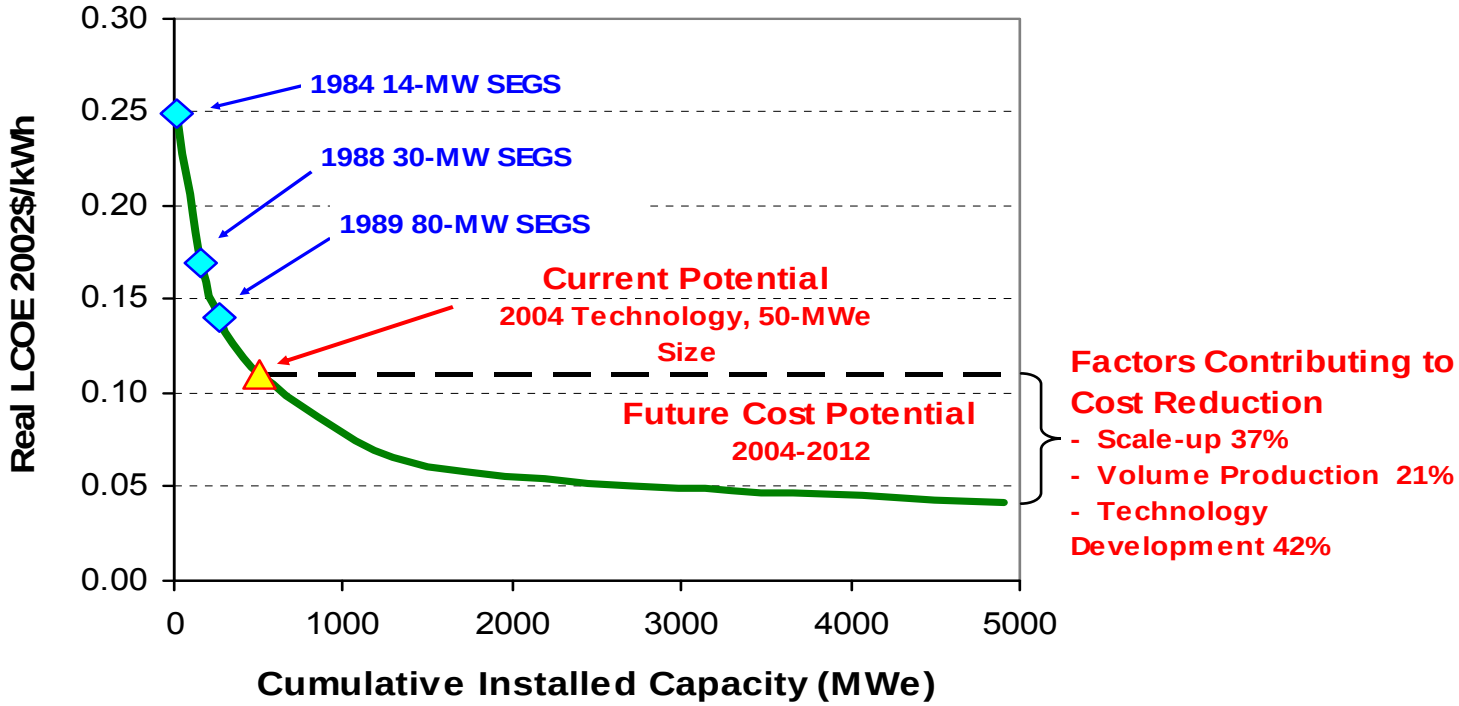
Improvements Needed for Intermediate Load Plants @ Cost Parity:

1. Thermal storage R&D – supporting an operating temperature of 500C (up from today's 390C)
2. Trough collector and receiver – increase optical accuracy necessary for producing heat transfer fluid at 500C and improve receiver coating to enable operation at 500C

Improvements Needed for Base Load Power Plants @ Cost Parity:

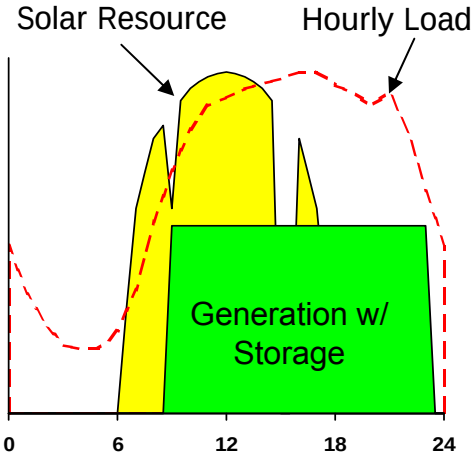
1. Advanced technology - higher operating temperature (e.g. power tower or dish) or simpler design (e.g. Fresnel concentrator)
2. Thermal storage – supporting operating temperatures of 650C or higher

CSP cost reduction and installations are facilitated through scale-up of demo's into large-field projects



Additional FY07 funds and FY08 request will support new push for industry-led CSP plant development

1. Thermal Storage R&D – enabling solar generated power to be delivered to grid any time it is needed by utilities
   - ❑ System concepts that reduce cost and improve cycle efficiency
   - ❑ Storage materials that operate at elevated temperatures and easily handled at ambient temperatures
   - ❑ Heat transfer fluids that can operate at elevated temperatures



2. Transition to High Volume Manufacturing – reduce costs and increase supply base for critical components
   - ❑ Glass or plastic mirrors for solar collectors
   - ❑ Thermal receivers
   - ❑ Collector or field electronics or controls

3. Advanced Concepts – explore new technologies that could significantly reduce system and/or component cost
   - ❑ New industry concepts such as linear Fresnel and Distributed Power Tower
   - ❑ Novel, low cost heliostats, dish or trough structures
   - ❑ Alternative materials for reflectors, absorbers, or structures

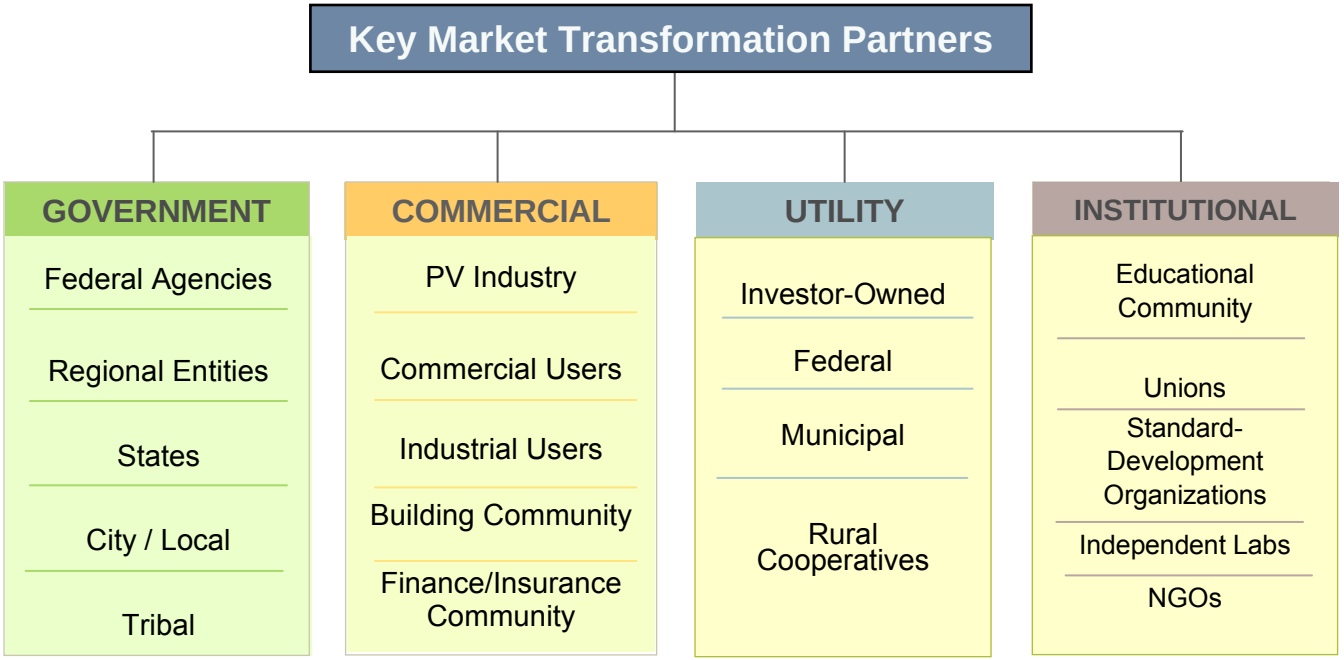
Market Transformation Activities

Establishing a Favorable Environment for Low-Cost Solar Technology

DOE engaged solar stakeholders in multiple forums to identify market barriers

The following resources were used to identify and prioritize market transformation activities:

1. Guidance of a strategic planning team composed of Federal and laboratory personnel with expertise in market transformation areas.
2. Input collected during two Technical Exchange Meetings (TEM) held in June 2006 in Washington, D.C., and San Francisco, California.
3. An official Request for Information (RFI) issued by DOE to solicit input from stakeholders for the strategic planning process.



DOE identified significant market barriers to solar technology commercialization

- Lack of communication, information dissemination, and consumer awareness
- Inadequate codes and standards
- Lack of appropriate, consistent interconnection standards
- Lack of equitable and effective net-metering guidelines
- Inconsistent utility rate structure practices
- Complex permitting procedures and fees
- Inconsistent and lack of widespread incentives and other drivers
- Limited education/experience of key building trades with solar technology
- Lack of trained technical personnel, reliable installers, and maintenance services
- Lack of flexible, sophisticated, proven financial approaches

SAI market transformation activities address two broad objectives

Reduce barriers to the commercialization of solar energy technologies

- Support the development of codes and standards that facilitate the installation of solar technologies
- Improve grid integration and net metering practices
- Provide information and best practices to state government officials
- Support a trained workforce able to meet future increases in solar technology demand

Promote market expansion of solar energy technologies

- Build partnerships with cities to aggressively promote solar technologies within national electricity load centers.
- Support the installation of novel solar technologies into replicable large-scale high visibility solar installations.

Market barriers increase the price of solar systems and the time to commercialization. Market transformation activities reduce costs and time, resulting in widespread deployment.

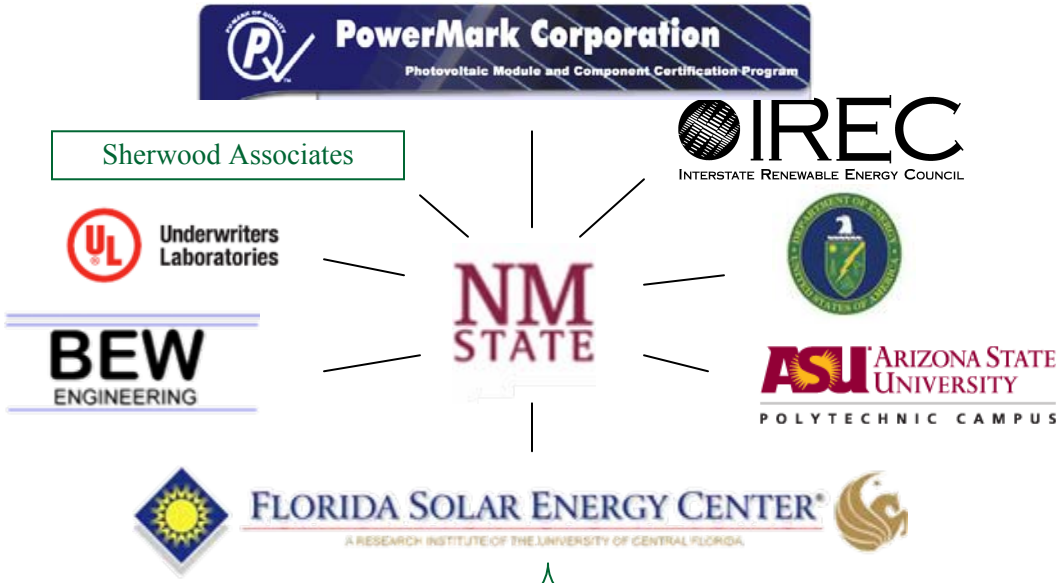
Solar America Board of Codes and Standards

Winner: New Mexico State University (collaborative)

Activity Objectives:

- Improve the responsiveness, effectiveness, and accessibility of codes and standards in all markets (federal, state, local, utility).
- Focus on codes and standards supports new technologies of the SAI Technology Pathway Partnerships.
- Codes and Standards are the backbone of the success of SAI. Without consistent support for codes and standards development, solar cannot be deployed on a large-scale.

New Mexico State University
Solar America Board of Codes and Standards



Building and Electrical Codes
Article 690 Guidance

Product Safety
Reconcile UL1703/IEC61730, UL 1741/IEC32109

National Standards Coordination
Revise IEEE 1547

Interconnection, Net Metering
Create Model Local Codes

International Standards Coordination
Monitor International Codes and Standards; Centralize U.S. participation

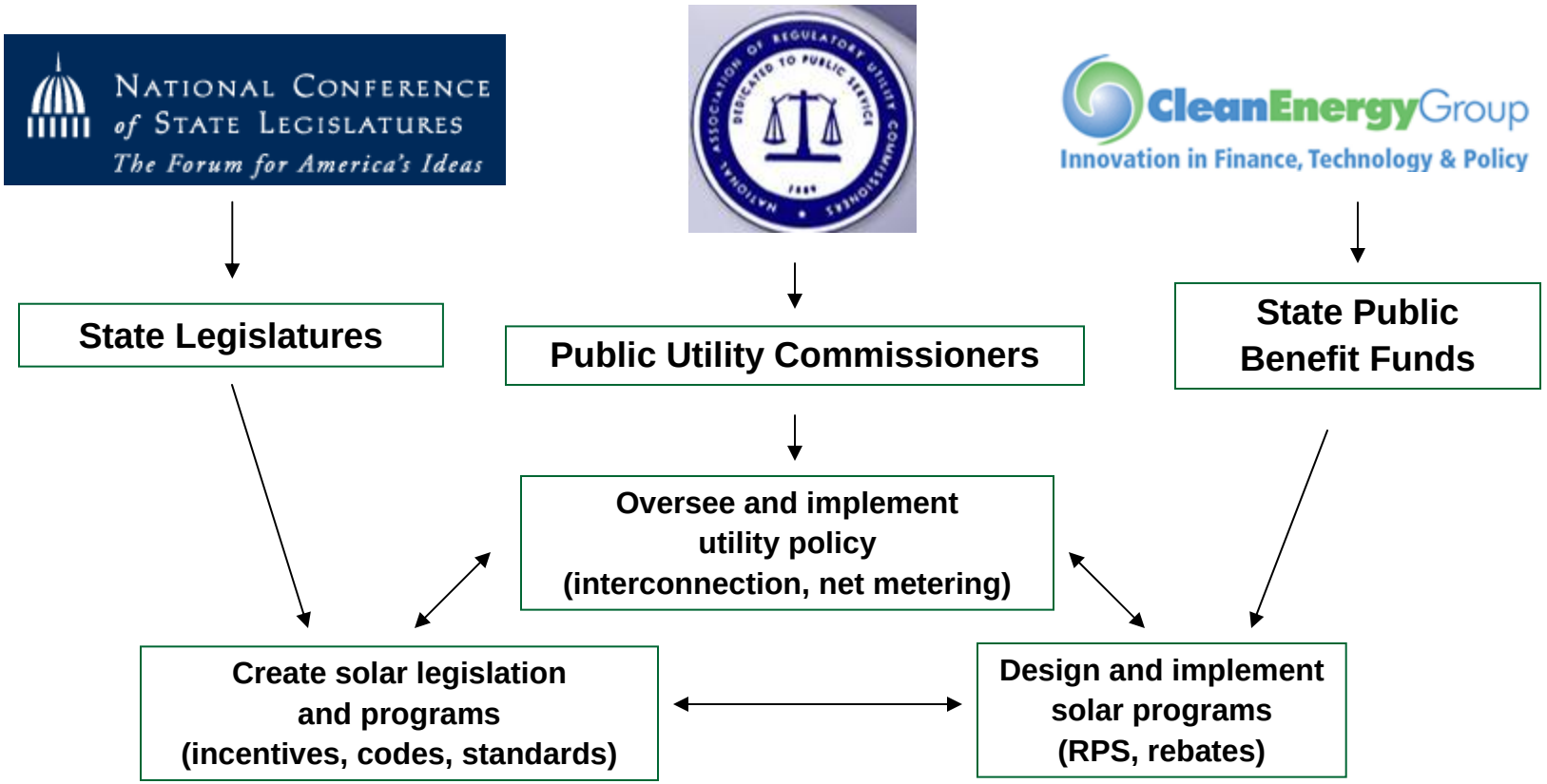
State Technical Outreach

Winners: National Conference of State Legislatures
Clean Energy Group
National Association of Regulatory Utility Commissioners

Activity Objectives:

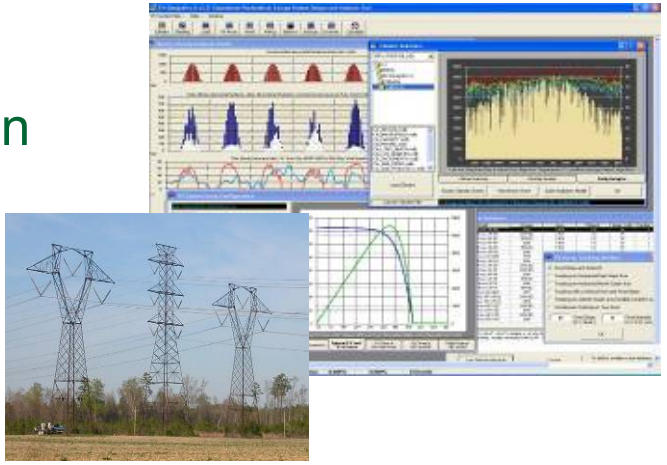
- Build relationships with State decision-makers (such as State legislatures, energy offices, public utility commissions and air quality offices) responsible for enacting policies, programs, and plans that are key drivers for solar technology market transformation.
- Provide key state actors with solar best practices and up-to-date, accurate information about solar technology, so they are positioned make informed solar policy decisions

National Conference of State Legislatures
Clean Energy Group
National Association of Regulatory Utility Commissioners



Utility Technical Outreach

Winner: Solar Electric Power Association



Activity Objectives:

- Utilities are critical to reach the SAI goals through their ability to enable sweeping progressive changes across large market areas for solar technologies.
- Enlist the assistance of a utility membership organization to deliver key technical and informational assistance to utilities to promote their acceptance and use of solar.

Solar Electric Power Association (SEPA)

Utility Technical Outreach

SEPA will assist their 175 member organizations and non-member utilities in the following ways:

- **Develop business cases for solar**
- **Provide current information on solar technologies**
- **Disseminate innovative solar program design information to utilities**

Solar America Cities

Activity Objectives:

- Partner with cities committed to achieving a sustainable solar infrastructure through a comprehensive, city-wide approach to solar technology that facilitates mainstream adoption and provides a model for other cities to follow.

Project Overview

- The selected cities will receive a combined $2.5 M in DOE funding plus substantial hands on assistance in their plans to:
  - Integrate solar technologies into city energy planning, zoning and facilities
  - Streamline city-level regulations and practices that affect solar adoption by residents and local businesses – including permitting, inspections, local codes
  - Promote solar technology among residents and local businesses through outreach, curriculum development, incentive programs, and other innovative approaches
- To ensure maximum impact, cities were required to submit a letter of support from their mayors and local utilities.

FY 2007 Solar America Cities

The 13 Solar America Cities selected in 2007 are:

- **Ann Arbor, MI**
- **Austin, TX**
- **Berkeley, CA**
- **Boston, MA**
- **Madison, WI**
- **New Orleans, LA**
- **New York, NY**
- **Pittsburgh, PA**
- **Portland, OR**
- **Salt Lake City, UT**
- **San Diego, CA**
- **San Francisco, CA**
- **Tucson, AZ**

Eight are among the largest 50 cities in the U.S.

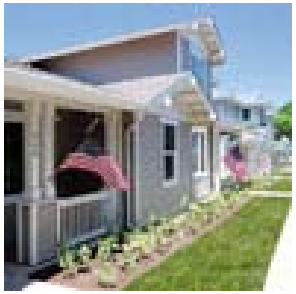
Solar America Cities are located in 11 states.

Solar America Showcases

Activity Objective:

Provide technical assistance to large-scale, high-impact solar installation projects initiated by businesses, developers, cities, states or other entities that showcase replicable novel solar technologies.

Selected Showcases include:



Forest City Military Communities, Hawaii

Orange County Convention Center, Florida

City of San Jose, California